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Land Use Management
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Water Monitoring Project
Water Monitoring and Standards
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# RARITAN and SANDY HOOK BAYS

# SANITARY SURVEY REPORT

# 1997-2000

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# RARITAN and SANDY HOOK BAYS SANITARY SURVEY REPORT 1997-2000

New Jersey Department of Environmental Protection
BRADLEY M. CAMPBELL
COMMISSIONER

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## *EXECUTIVE SUMMARY*

This report is a Sanitary Survey of the Raritan and Sandy Hook Bays. A Sanitary Survey is completed every 12 years for each designated growing area, when there have been significant changes in the area, or if an upgrade in classification is proposed. The report addresses a request from the shellfish industry to review the water quality of the *Prohibited* waters at the eastern and western portions of the area. A classification upgrade (*Prohibited* to *Special Restricted*) would allow the shellfish resources to be utilized under the special permit program for depuration and relay.

Sampling results (1997-2000) indicate that the total coliform bacterial water quality of the shellfish growing waters of the Raritan and Sandy Hook Bays has improved slightly since the last Sanitary Survey report that covered sampling results from 1994-1996. This improvement is part of a continuing trend in water quality improvement in this area. There appears to be an overall improvement in bacterial water quality in the Sandy Hook Bay.

This report includes an evaluation of tissue samples analyzed for a suite of toxicants, including heavy metals and organic compounds. An evaluation of the potential impacts from the Middlesex County Utilities Authority discharge, located in the western section of Raritan Bay, is also included. Based on these data, an upgrade was implemented for a triangular area to the west of Sandy Hook (known as Flynn's Knoll) as well as a smaller area to the west of Conaskonk Point. The total area upgraded (from *Prohibited* to *Special Restricted*) is approximately 5714 acres.

## *INTRODUCTION*

### PURPOSE

This report is part of a series of studies having a dual purpose. The first and primary purpose is to comply with the guidelines of the National Shellfish Sanitation Program (NSSP) that are established by the Interstate Shellfish Sanitation Conference (ISSC). Reports generated under this program form the basis for classifying shellfish waters for the purpose of harvesting shellfish for human consumption. As such, they provide a critical link in protecting human health.

The second purpose is to provide input to the State Water Quality Inventory Report, which is prepared pursuant to Section 305(b) of the Federal Clean Water Act (P.L. 95-217). The information contained in the growing area reports is used for the New Jersey State Water Quality Inventory Report (305b), which provides an assessment to Congress every two years of current water quality conditions in the State's major rivers, lakes, estuaries, and ocean waters. The reports provide valuable

information for the 305(b) report, which describes the waters that are attaining state designated water uses and national clean water goals; the pollution problems identified in surface waters; and the actual or potential sources of pollution. Similarly, the reports utilize relevant information contained in the 305(b) report, since the latter assessments are based on instream monitoring data (temperature, oxygen, pH, total and fecal coliform bacteria, nutrients, solids, ammonia and metals), land-use profiles, drainage basin characteristics and other pollution source information.

From the perspective of the Shellfish Classification Program, the reciprocal use of water quality information from reports represent two sides of the same coin: the growing area report focuses on the estuary itself, while the 305(b) report describes the watershed that drains to that estuary.

The Department participates in a cooperative National Environmental Performance Partnership System (NEPPS) with the USEPA, which emphasizes ongoing evaluation of the effectiveness of environmental management strategies, including assessing impacts on waterbodies and measuring improvements in various indicators of environmental health. One of the indicators used to assess the environmental health of coastal waters is the area of waters classified as harvestable (*Approved*, *Seasonally Approved*, or *Special Restricted*).

The shellfish growing area reports provide a brief assessment of the growing area, with particular emphasis on those factors that affect the quantity and quality of the shellfish resource. As the Department implements a comprehensive watershed management program in conjunction with the NEPPS initiative, the shellfish growing area reports provide valuable information on the overall quality of the saline waters in the most downstream sections of each major watershed. In addition, the reports assess the quality of the biological resource and provide a reliable indicator of potential areas of concern and/or areas where additional information is needed to accurately assess watershed dynamics.

## HISTORY

As a brief history, the NSSP developed from public health principles and program controls formulated at the original conference on shellfish sanitation called by the Surgeon General of the United States Public Health Service in 1925. This conference was called after oysters were implicated in causing over 1500 cases of typhoid fever and 150 deaths in 1924. The tripartite cooperative program (federal, state and shellfish industry) has updated the program procedures and guidelines through workshops held periodically until 1977. Because of concern by many states that the NSSP guidelines were not being enforced uniformly, a delegation of state shellfish officials from 22 states met in 1982 in Annapolis, Maryland, and formed the ISSC. The first annual meeting was held in 1983 and the organization continues to meet annually at various locations throughout the United States.

The NSSP *Guide for the Control of Molluscan Shellfish* sets forth the principles and requirements for the sanitary control of shellfish produced and shipped in interstate commerce in the United States. It provides the basis used by the Federal Food and Drug Administration (FDA) in evaluating state shellfish sanitation programs. The five major points on which each state is evaluated by the FDA include:

1. The classification of all actual and potential shellfish growing areas as to their suitability for shellfish harvesting.
2. The control of the harvesting of shellfish from areas that are classified as restricted, prohibited or otherwise closed.
3. The regulation and supervision of shellfish resource recovery programs.
4. The ability to restrict the harvest of shellfish from areas in a public health emergency, and
5. Prevent the sale, shipment or possession of shellfish that cannot be identified as being produced in accordance with the NSSP and have the ability to condemn, seize or embargo such shellfish.

## FUNCTIONAL AUTHORITY

The authority to carry out these functions is divided between the Department of Environmental Protection (DEP), the Department of Health and Senior Services and the Department of Law and Public Safety. The Bureau of Marine Water Monitoring (BMWM) under the authority of N.J.S.A. 58:24 classifies the shellfish growing waters and administers the special resource recovery programs. Regulations delineating the growing areas are promulgated at N.J.A.C. 7:12 and are revised annually. Special Permit rules are also found at N.J.A.C. 7:12 and are revised as necessary.

The Bureau of Shellfisheries in the Division of Fish and Wildlife issues harvesting licenses and leases for shellfish grounds under the Authority of N.J.S.A. 50:2 and N.J.A.C. 7:25. This bureau administers the Hard Clam Relay Program in conjunction with the BMWM.

The Bureau of Law Enforcement in the DEP (Division of Fish and Wildlife) and the Division of State Police in the Department of Law and Public Safety enforce the provisions of the statutes and rules mentioned above.

The Department of Health and Senior Services is responsible for the certification of wholesale shellfish establishments, and in conjunction with the BMWM, administers the depuration program.

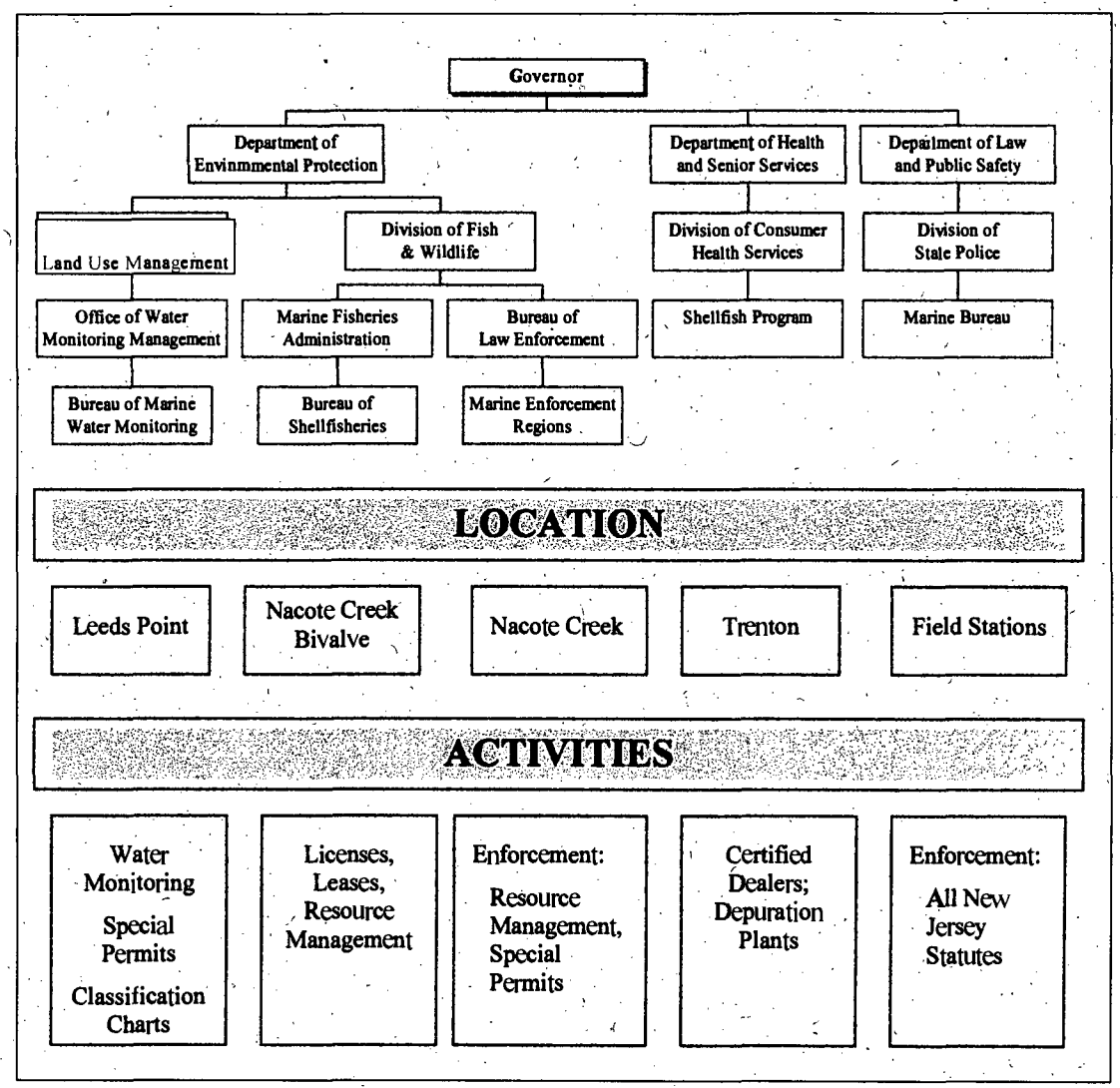



Figure 1: State of New Jersey Shellfish Agencies

## IMPORTANCE OF SANITARY CONTROL OF SHELLFISH

Emphasis is placed on the sanitary control of shellfish because of the direct relationship between pollution of shellfish growing areas and the transmission of diseases to humans. Shellfish borne infectious diseases are generally transmitted via a fecal-oral route. The pathway is complex and quite circuitous. The cycle usually begins with fecal contamination of the shellfish growing waters. Sources of such contamination are many and varied. Contamination reaches the waterways via runoff and direct discharges.

Clams, oysters and mussels pump large quantities of water through their bodies during the normal feeding process. During this process the shellfish also concentrate microorganisms, which may

include pathogenic microbes, and toxic heavy metals and synthetic organic contaminants. It is imperative that a system is in place to reduce the human health risk of consuming shellfish from areas of contamination.

Accurate classifications of shellfish growing areas are completed through a comprehensive sanitary survey. The principal components of the sanitary survey report include:

- ? An evaluation of all actual and potential sources of pollution,
- ? An evaluation of the hydrography of the area and
- ? An assessment of water quality.

Complete intensive sanitary surveys are conducted every 12 years with interim narrative evaluations completed on a three year basis. If major changes to the shoreline or bacterial quality occur, then the intensive report is initiated prior to its 12 year schedule.

The following narrative constitutes this bureau's assessment of the components listed above and determines the current classification of the shellfish growing waters.

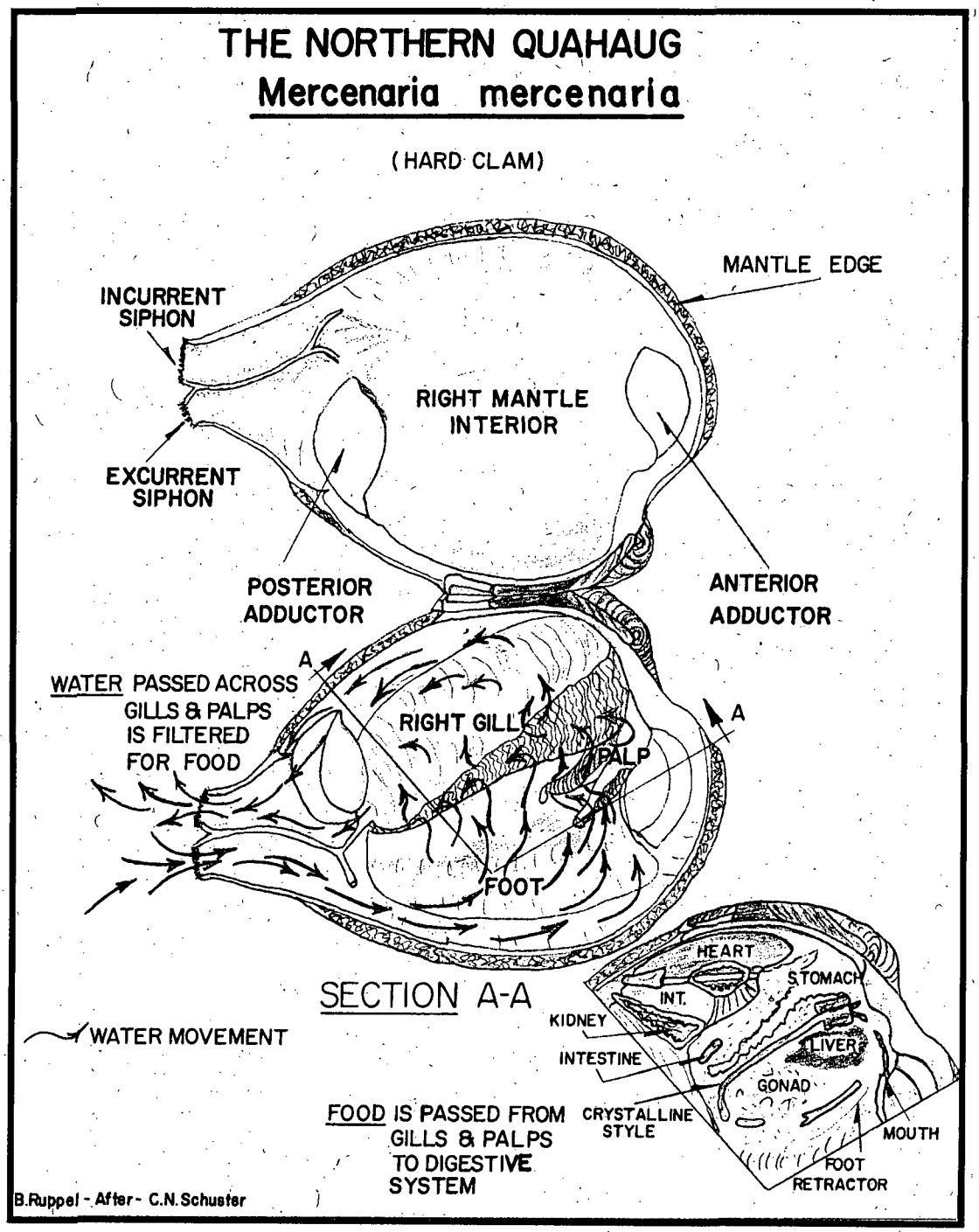



FIGURE 2: CROSS-SECTION OF *MERCENARIA MERCENARIA*

## *DESCRIPTION*

## LOCATION

This growing area encompasses the shellfish waters of Sandy Hook Bay and Raritan Bay. The area, located in northern Monmouth County, New Jersey, extends from the Highlands Bridge northward to Sandy Hook and westward to the Raritan River. The distance from the Highlands Bridge to the mouth of the Raritan River is approximately 17 miles. To the north the area terminates along the New York State Boundary Line. The shellfish resources are harvested from an area covering approximately 7438 acres (11.6 square miles) of *Special Restricted* shellfish waters.

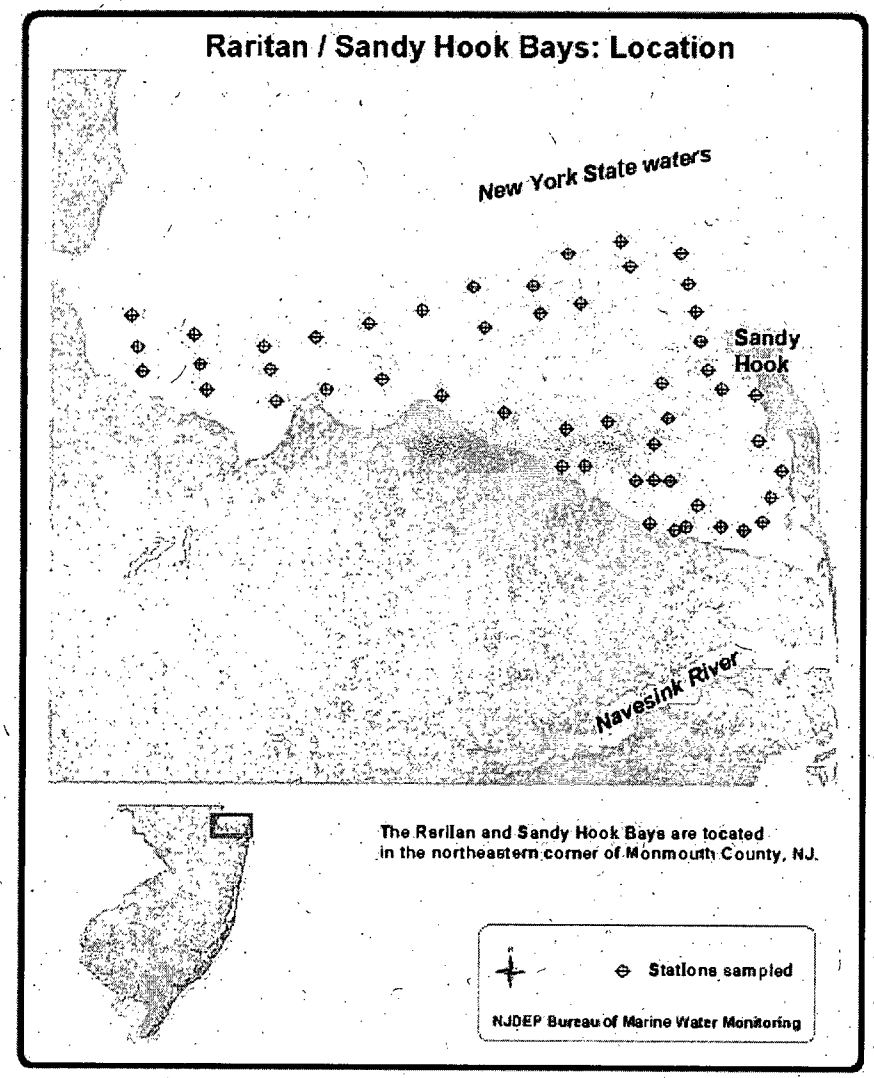



FIGURE 3: LOCATION OF RARITAN / SANDY HOOK BAYS

Raritan Bay (22,400 acres) is located adjacent to the nation's most-concentrated urban population. Sandy Hook Bay (7,680 acres) is located to the east, is contiguous with, and empties into, Raritan Bay. The area is also shown on Shellfish Growing Water Classification Chart 1. The Shellfish Growing Water Classification Charts are published annually by the Department of Environmental Protection to provide readily accessible information to the public.

## DESCRIPTION

Sandy Hook Bay is triangular in shape, and extends from the shore at Leonardo, approximately two miles into the bay. On the southwest side of the triangle is the Earle Naval Weapons pier. Sandy Hook borders the eastern side of the bay. This narrow peninsula or spit separates the bay from the Atlantic Ocean. At the outer tip of Sandy Hook are Fort Hancock and the United States Coast Guard installation. The remainder of the peninsula is part of the Gateway National Recreation Area. The communities of Highlands, Atlantic Highlands, and Leonardo border the southern shoreline of Sandy Hook Bay.

The waters of Raritan and Sandy Hook Bays are classified as *Special Restricted* or *Prohibited* for the harvest of shellfish. Clams may be harvested for human consumption from *Special Restricted* waters under the Special Permits program. These clams undergo further purification prior to market. Harvest of shellfish for human consumption is not permitted in *Prohibited* waters.

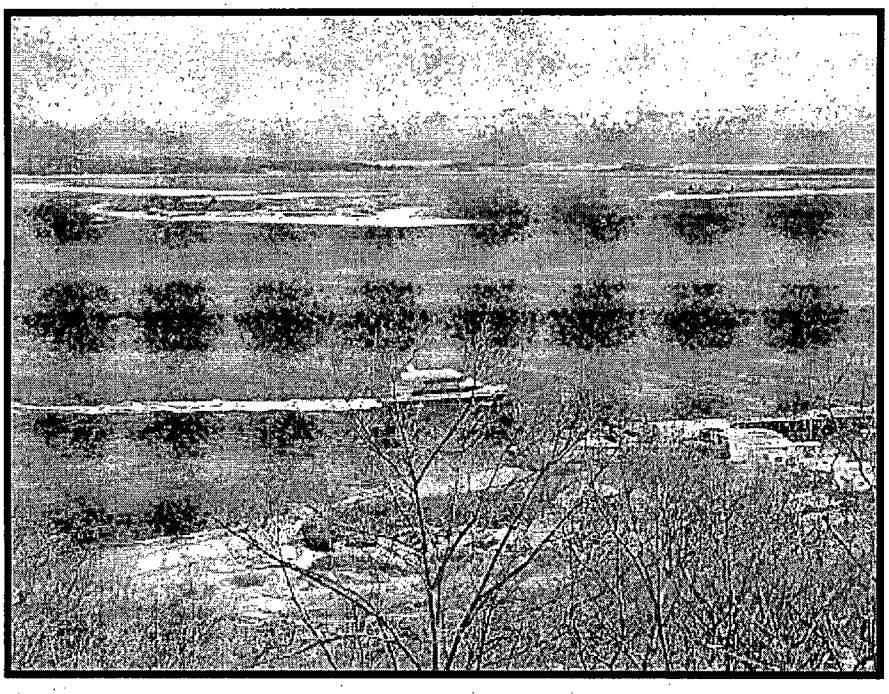


FIGURE 4: SANDY HOOK BAY, LOOKING NORTHEAST FROM MT. MITCHELL

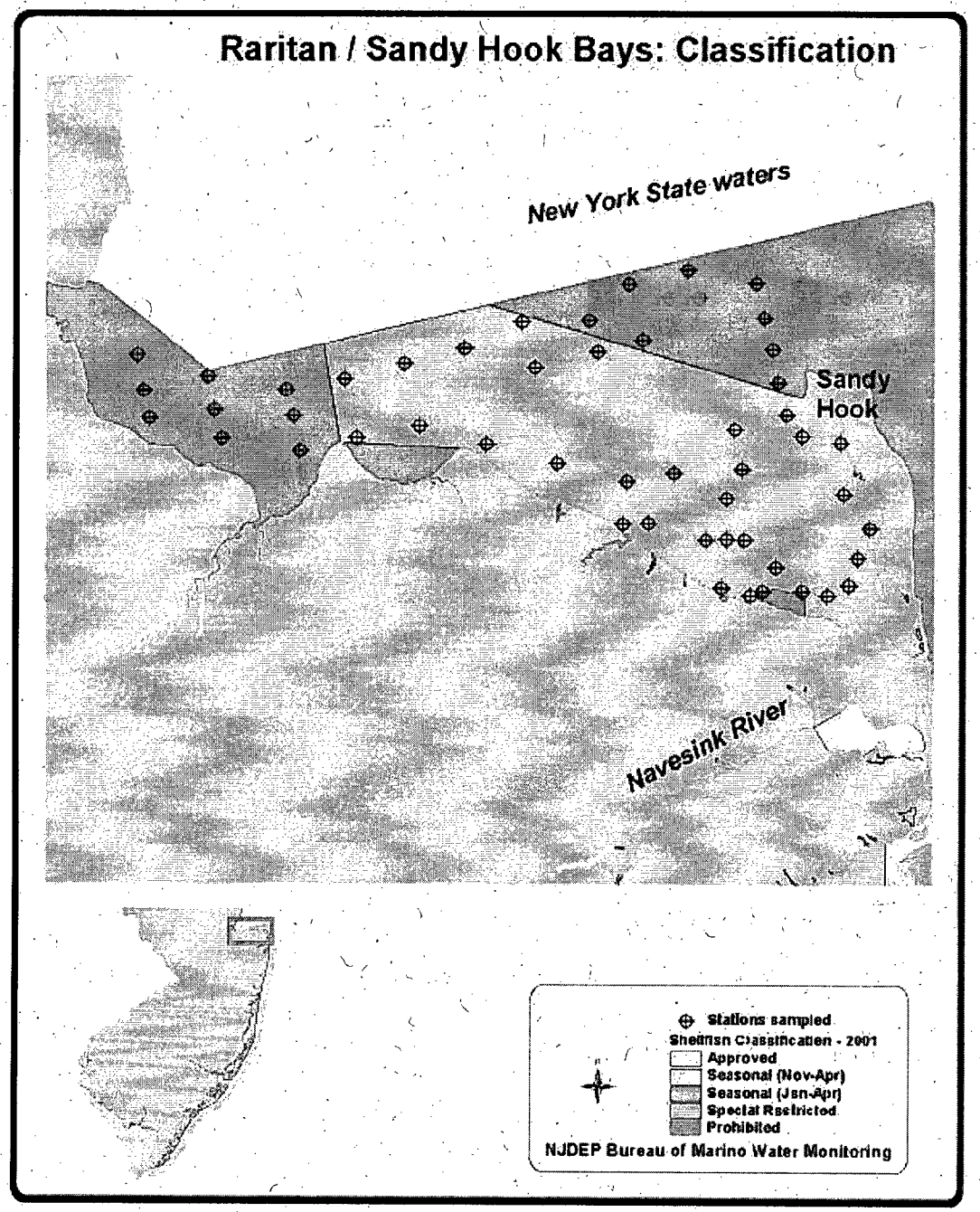



FIGURE 5: CURRENT CLASSIFICATION OF RARITAN / SANDY HOOK BAYS

## HISTORY

This area is heavily used during the summer months for recreational purposes. There are numerous marinas (see section discussing marina activities). The area has been used extensively for shellfishing for many years. There was a period in the early 1970's when the area was classified as *Prohibited.* However, as upgraded regional domestic treatment facilities were constructed, water quality gradually improved. Most of the area is currently classified as *Special Restricted.*

This report recommends upgrading acreage in the area of Flynn's Knoll (directly west of Sandy Hook). This area is currently classified as *Prohibited*; the upgrade would classify the area as *Special Restricted.* In addition, it is feasible that a portion of Sandy Hook Bay may eventually be upgraded to *Seasonally Approved.*

The last Sanitary Survey of this area was completed in 1999.

## *METHODS*

Water sampling was performed in accordance with the Field Procedures Manual (NJDEP, 1992).

Approximately 632 water samples were collected for total and fecal coliform bacteria between May 1, 1997 and October I, 2000 and analyzed by the three-tube MPN method according to APHA (1970). Figure 5 shows the Shellfish Growing Water Quality monitoring stations in Raritan and Sandy Hook Bays. Approximately 51 stations are monitored each year.

Water quality sampling, shoreline and watershed surveys were conducted in accordance with the NSSP *Guide for the Control of Molluscan Shellfish,* 1997.

Data management and analysis was accomplished using Visual Basic applications. Geographic analysis and display of data was performed with an ArcView? Geographic Information System (GIS).

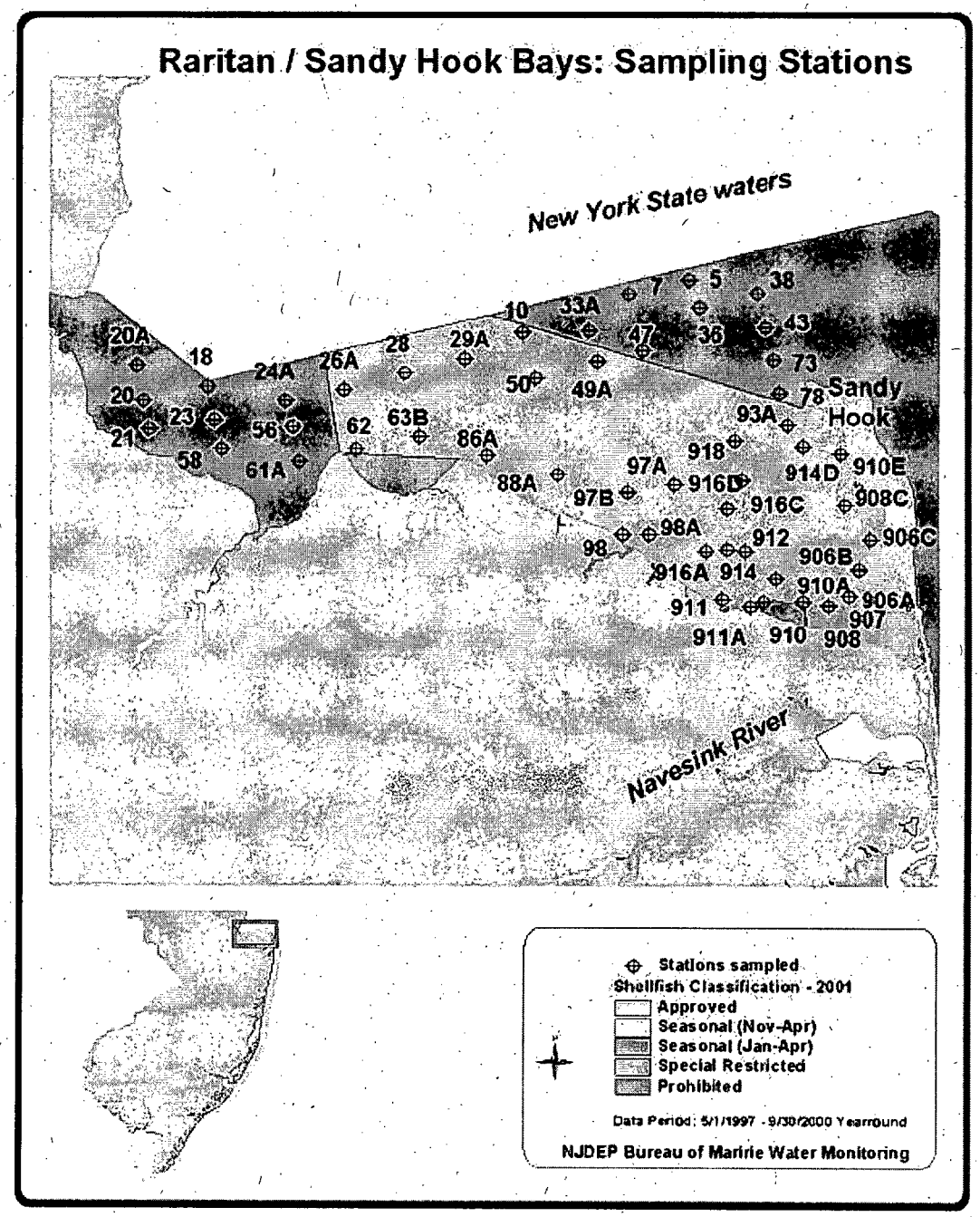



FIGURE 6: SAMPLING STATIONS

## BACTERIOLOGICAL INVESTIGATION AND DATA ANALYSIS

The water quality of each growing area must be evaluated before an area can be classified as *Approved, Seasonally Approved, Special Restricted,* or *Seasonal Special Restricted.* Criteria for bacterial acceptability of shellfish growing waters are provided in the NSSP *Guide for the Control of Molluscan Shellfish,* 1997.

### *SAMPLING STRATEGY*

The State Shellfish Control Authority has the option of choosing one of two water monitoring sampling strategies for each growing area.

The Adverse Pollution Condition Strategy requires that a minimum of five samples be collected each year under conditions that have historically resulted in elevated coliform levels in the particular growing area. The results must be evaluated by adding the individual station sample results to the preexisting bacteriological sampling results to constitute a data set of at least 15 samples for each station. The adverse pollution conditions usually are related to tide, and rainfall, but could be from a point source of pollution or variation could occur during a specific time of the year.

The Systematic Random Sampling Strategy requires that a random sampling plan be in place before field sampling begins. This strategy can only be used in areas that are not affected by point sources of contamination. A minimum of six samples per station are to be collected each year and added to the database to obtain a sample size of 30 for statistical analysis.

The Raritan and Sandy Hook Bays are sampled under the Adverse Pollution Condition of rainfall.

### *NSSP CRITERIA*

Each shellfish producing state is directed to adopt either the total coliform criterion, or the fecal coliform criterion. While New Jersey bases its growing water classifications on the total coliform criterion, it does make corresponding fecal coliform determinations for each sampling station. These data are viewed as adjunct information and are not directly used for classification.

The criteria were developed to ensure that shellfish harvested from the designated waters would be free of pathogenic (disease-producing) bacteria.

Each classification criterion is composed of a measure of the statistical 'central tendency' (geometric mean) and the relative variability of the data set. For the Adverse Pollution Condition sampling strategy, variability is expressed as the percentage that exceeds the variability criteria. For the Systematic Random Sampling Strategy, variability is expressed as the 90$^{th}$ percentile.

Areas to be *Approved* under the *Seasonal* classification must be sampled and meet the criterion during the time of the year that it is approved for the harvest of shellfish.

TABLE 1: CRITERIA FOR ADVERSE POLLUTION CONDITION SAMPLING STRATEGY

| | Total Coliform Criteria | | Fecal Coliform Criteria | |
|---|---|---|---|---|
| | Geometric mean (MPN/100 mL) | No more than 10% can exceed (MPN/100 mL) | Geometric mean (MPN/100 mL) | No more than 10% can exceed (MPN/100 mL) |
| Approved Water Classification | 70 | 330 | 14 | 49 |
| Special Restricted Water Classification | 700 | 3300 | 88 | 300 |

TABLE 2: CRITERIA FOR SYSTEMATIC RANDOM SAMPLING STRATEGY

| | Total Coliform Criteria | | Fecal Coliform Criteria | |
|---|---|---|---|---|
| | Geometric mean (MPN/100 mL) | Maximum 90$^{th}$ percentile (MPN/100 mL) | Geometric mean (MPN/100 mL) | Maximum 90$^{th}$ percentile (MPN/100 mL) |
| Approved Water Classification | 70 | 330 | 14 | 49 |
| Special Restricted Water Classification | 700 | 3300 | 88 | 300 |

## MARINE BIOTOXINS

The Department collects samples at regular intervals throughout the summer to determine the occurrence of phytoplankton that can produce marine biotoxins such as saxitoxin (the causative agent of paralytic shellfish poisoning). These data are evaluated weekly by the Bureau of Marine Water Monitoring in accordance with the NSSP requirements. An annual report is compiled and is available electronically at: *www.state.nj.us/dep/wmm/bmw*.

## *SHORELINE SURVEY*

## CHANGES SINCE LAST SURVEY

There were no significant changes in the shoreline in this area since the last sanitary survey.

## EVALUATION OF BIOLOGICAL RESOURCES

Raritan and Sandy Hook Bays contain abundant shellfish resources. In 1997 an estimated 32 million clams were taken from Raritan and Sandy Hook Bays under the Special Permit Program (combined relay and depuration) worth in excess of 11 million dollars (Joseph, 2001). Table 3 lists the combined relay and depuration harvest, effort, and catch-per- effort data for Raritan and Sandy Hook Bays. Designated harvest areas for the relay and depuration of hard and soft clams in the *Special Restricted* waters of Raritan and Sandy Hook Bays are shown below.

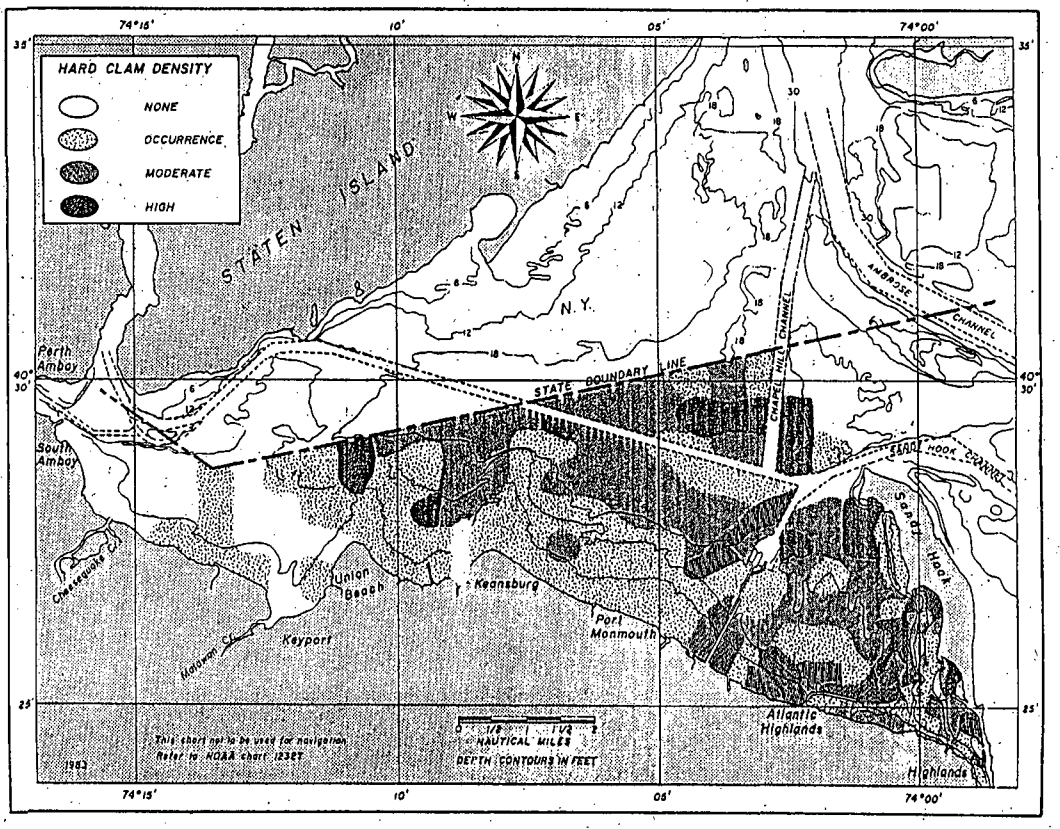



FIGURE 7: HARD CLAM RESOURCES IN RARITAN / SANDY HOOK BAY

FIGURE 8: SOFT CLAM RESOURCES IN RARITAN / SANDY HOOK BAY

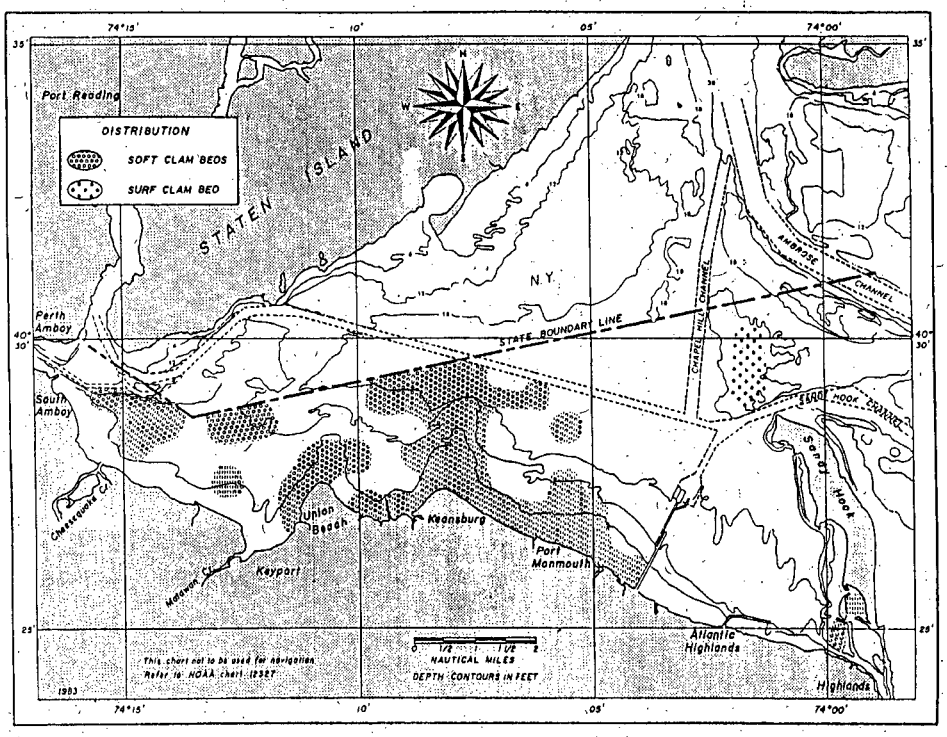
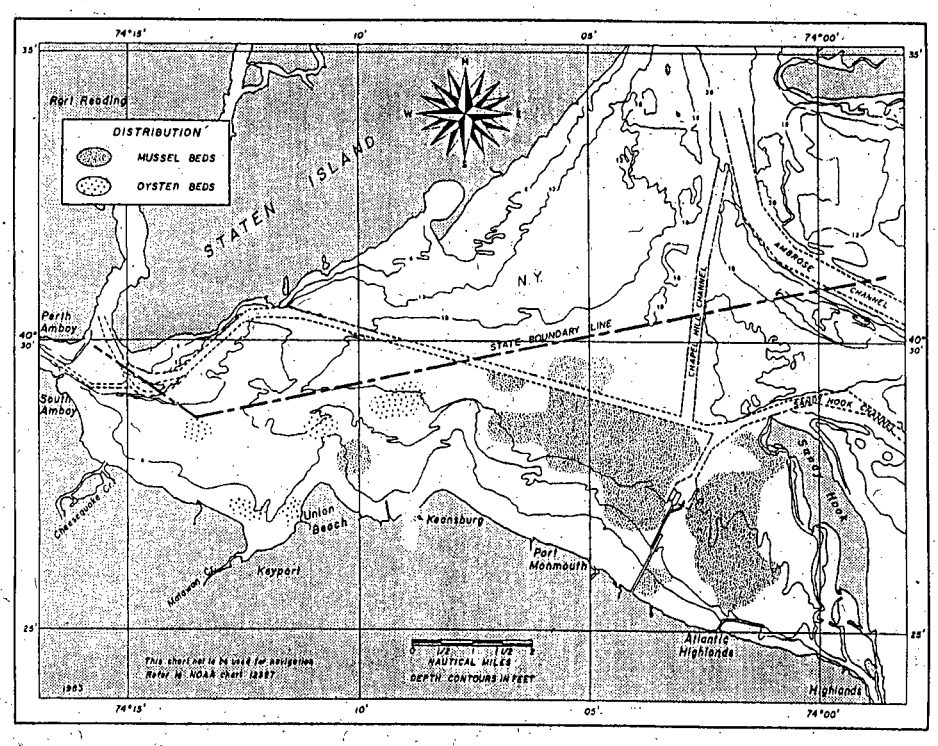



FIGURE 9: MUSSEL AND OYSTER RESOURCES IN RARITAN / SANDY HOOK BAY



## SPECIAL PERMITS PROGRAM

Clams harvested from waters classified as *Special Restricted* must be treated prior to sale for human consumption. Treatment may be through the depuration program, where clams are held in tanks in clean water for a period of time, or the relay program, where clams are placed in clean water in Barnegat Bay for a period of time. This process provides sufficient time for the clams to excrete any bacteria that may have adhered to the tissue prior to harvest. The James T. White clam depuration plant is located in Highlands. Another depuration plant, Clean Water Clams, is located to the south of the Highlands Bridge.

The implementation of shellfish resource recovery programs is a cooperative effort of State agencies involved with shellfish in New Jersey. The programs include the issuance of special permits to utilize bivalve mollusks harvested from *Special Restricted* waters. The permits contain special conditions relating to the collection, bacterial purging, and subsequent marketing of shellfish taken under the purview of the program and deemed necessary to protect public health.

Requests by the shellfish industry to utilize the extensive shellfish resources from the bay waters of Northern Monmouth County prompted the establishment of a Shellfish Resource Recovery Steering Committee. The committee is made up of representatives from the Department of Environmental Protection and the Department of Health and Senior Services, who have the regulatory responsibilities for administering the shellfish resource programs.

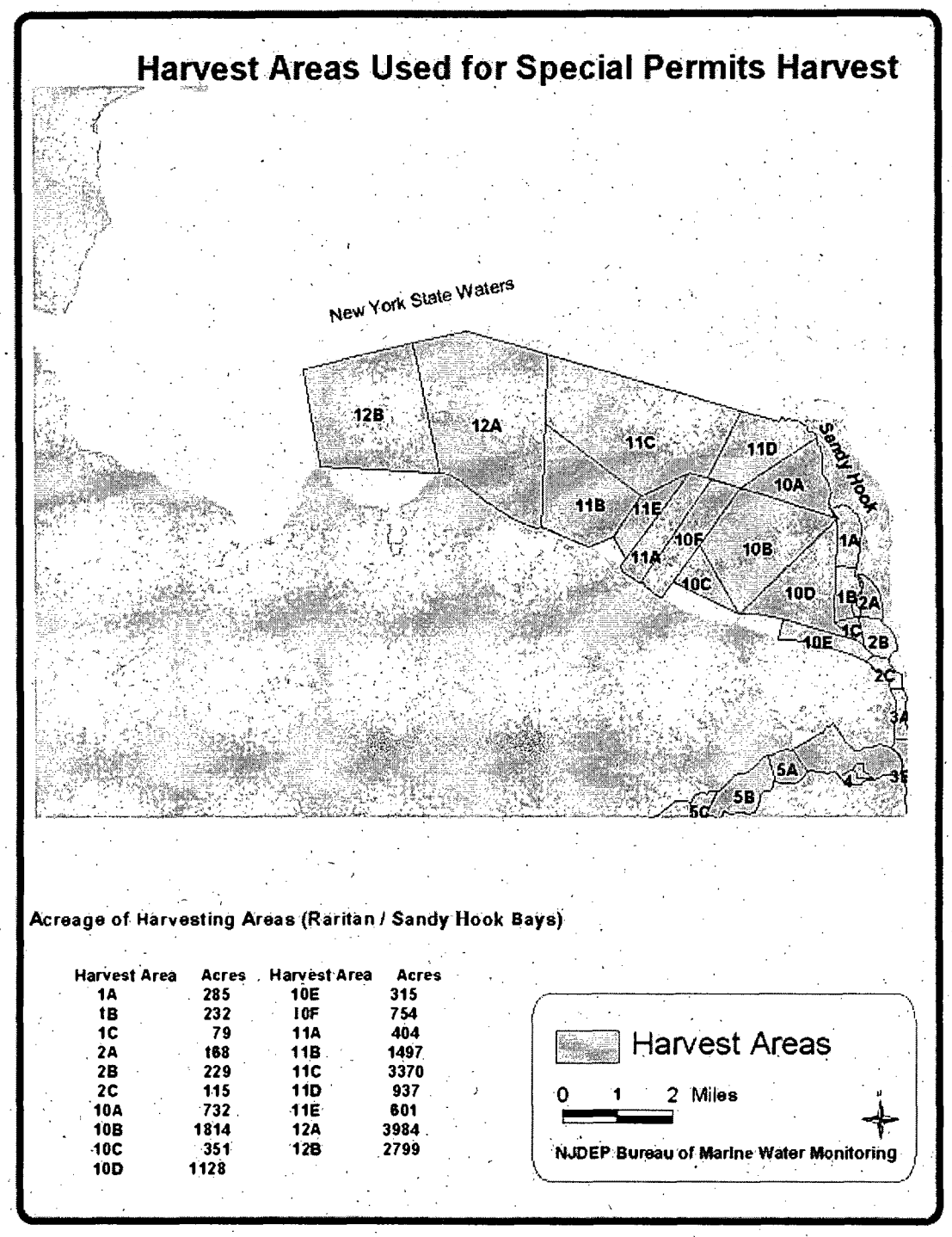
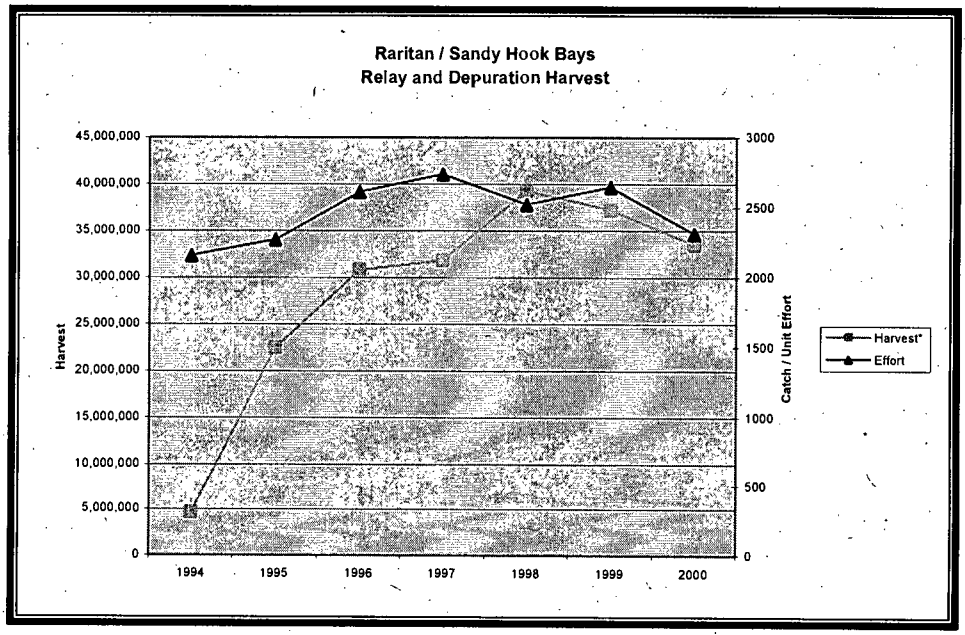



FIGURE 10: DESIGNATED HARVESTING AREAS IN RARITAN / SANDY HOOK BAYS

TABLE 3: COMBINED RELAY AND DEPURATION HARVEST, EFFORT, AND CATCH PER EFFORT

| YEAR | HARVEST (# of clams) | EFFORT (Man days) | CATCH/EFFORT (Clams/man/day) |
|---|---|---|---|
| 2000 | 33,527,929 | 14,496 | 2,313 |
| 1999 | 37,206,616 | 14,061 | 2,646 |
| 1998 | 39,284,830 | 15,580 | 2,522 |
| 1997 | 31,865,597 | 11,636 | 2,738 |
| 1996 | 30,818,784 | 11,794 | 2,613 |
| 1995 | 22,405,868 | 9,871 | 2,270 |
| 1994 | 4,589,602 | 2,127 | 2,158 |

FIGURE 11: RELAY AND DEPURATION HARVEST (1994-2000)




Source: New Jersey Division of Fish Game and Wildlife, Bureau of Shellfisheries, Nacote Creek Field Station.

## LAND USE

The shoreline is well developed with residential, business, and industrial areas. There are a few forested areas remaining and some inland areas still devoted to agriculture. The Borough of Highlands has the highest coastal point on the East Coast (from Maine to Florida) with an elevation in excess of

260 feet above sea level. Most of Sandy Hook remains undeveloped as a National Park with an active Coast Guard base at the northern end.

There are 5 municipalities in Middlesex County and 9 municipalities in Monmouth County that adjoin the Raritan / Sandy Hook Bay area. The area is relatively densely populated.

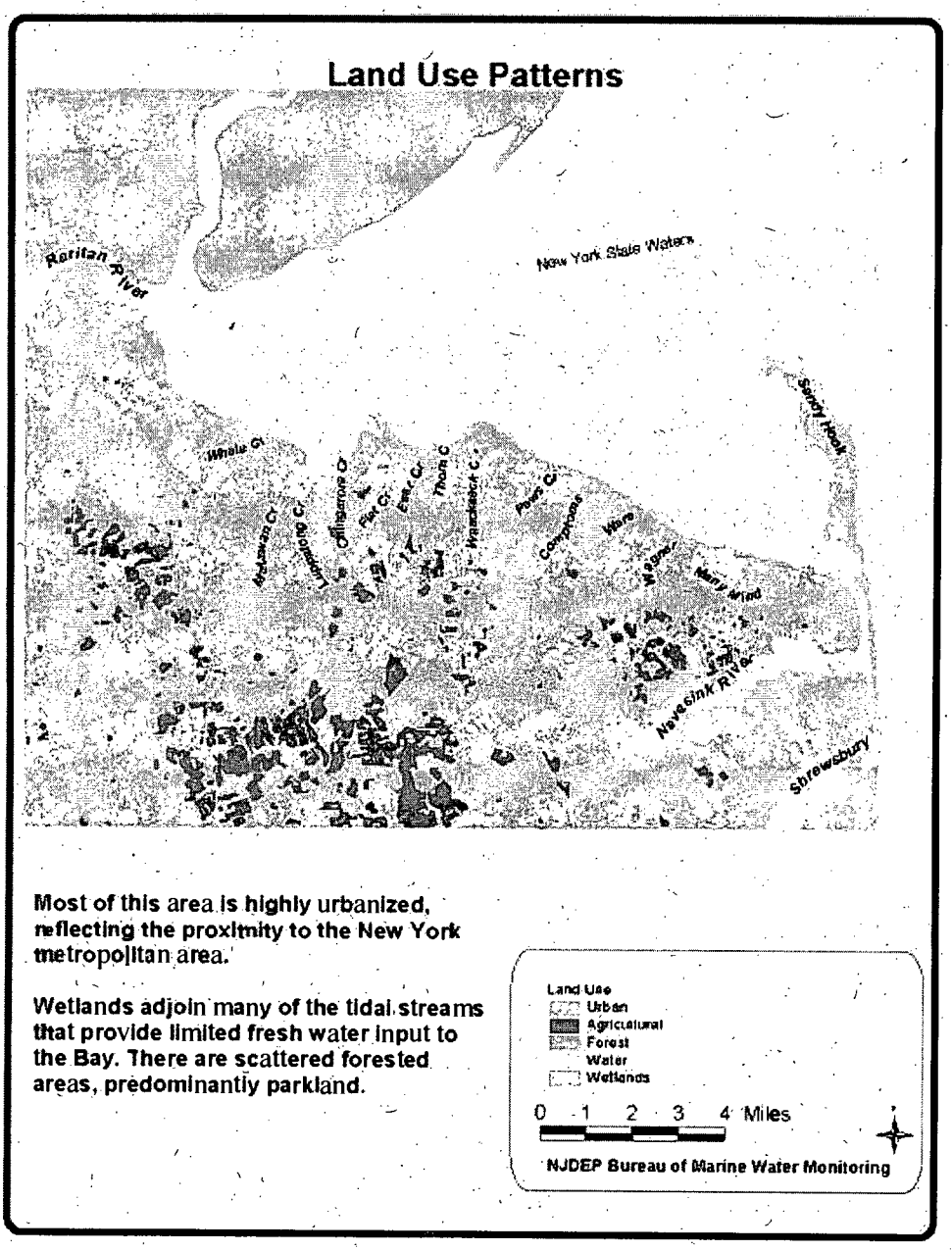



FIGURE 12: LAND USE PATTERNS

TABLE 4 : MUNICIPAL STATISTICS (1990 CENSUS)

| Municipality | 1990 Census | |
|---|---|---|
| | Population | Density (persons/mi$^2$) |
| **Middlesex County** | | |
| Woodbridge | 93086 | 3802 |
| Perth Amboy | 41976 | 7033 |
| Sayreville | 34986 | 1866 |
| South Amboy | 7863 | 3026 |
| Old Bridge | 56475 | 1376 |
| **Monmouth County** | | |
| Union Beach | 6156 | 3257 |
| Keansburg | 11069 | 9465 |
| Aberdeen Twp | 16720 | 3257 |
| Hazlet | 21976 | 3820 |
| Keyport | 7586 | 5181 |
| Middletown | 68183 | 1691 |
| Atlantic Highlands | 4629 | 3788 |
| Highlands | 4849 | 6696 |
| Sea Bright | 1693 | 1664 |

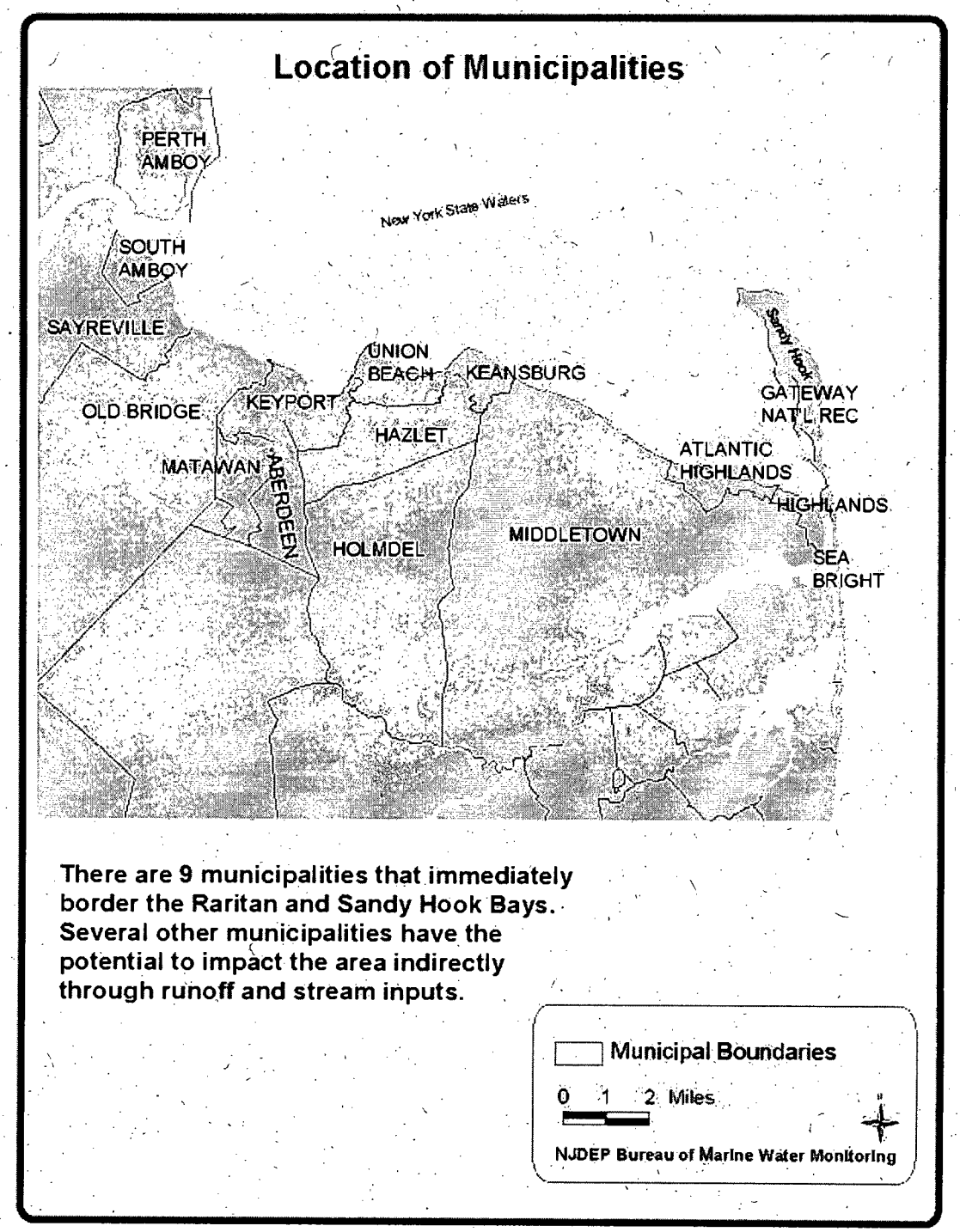



FIGURE 13: MUNICIPALITIES ADJOINING RARITAN / SANDY HOOK BAYS

# IDENTIFICATION AND EVALUATION OF SOURCES

## *PERMITTED POINT SOURCES*

The Raritan Bay estuary receives municipal and industrial wastes both directly and through the tributary waters of this area.

The *Special Restricted* shellfish waters do not receive any permitted discharges from wastewater treatment plants. However, Middlesex County Utilities Authority has a permitted 160 MGD outfall located in the *Prohibited* waters of Raritan Bay approximately 3 miles west of the *Special Restricted* waters. The peak flow rates from this outfall can exceed 150 MGD. The potential pathogenic impact of the discharge was evaluated in 1997 (Sobsey, 1997).

A supplemental outfall is located on the northern bank of the Raritan River adjacent to the treatment facility. The outfall is used when the flow is greater than 145 MGD. Peak flow from this outfall exceeds 150 MGD. In addition, since the permitted flow for the facility is 160 MGD and the excessive flows frequently occur during wet weather, these flows may result in inadequate treatment.

Monmouth County Bayshore Outfall Authority (MCBOA) operates an interceptor that conveys waste treated at Bayshore Regional Sewerage Authority and Middletown Township Sewerage Authority to an outfall located in the Atlantic Ocean approximately 1 mile offshore.

The potential impacts of these discharges are discussed below.

TABLE 5 : DIRECT DISCHARGES TO RARITAN AND SANDY HOOK BAYS

| Discharge | Waste Type | Waste Quantity (MGD) |
|---|---|---|
| Middlesex County Utilities Authority | Domestic | 160 (permitted) |
| Middlesex County (supplemental outfall) | Domestic | 150 |
| Bayshore Regional Sewerage Authority | Domestic | Discharges to MCBOA |
| Middletown Sewerage Authority | Domestic | Discharges to MCBOA |
| Gateway National Recreation Area | Domestic | 0.15; discharges to ground water |
| International Flavors and Fragrances | Industrial | No longer discharges |
| Monmouth County Bayshore Outfall Authority | Domestic | Discharges to Atlantic Ocean |

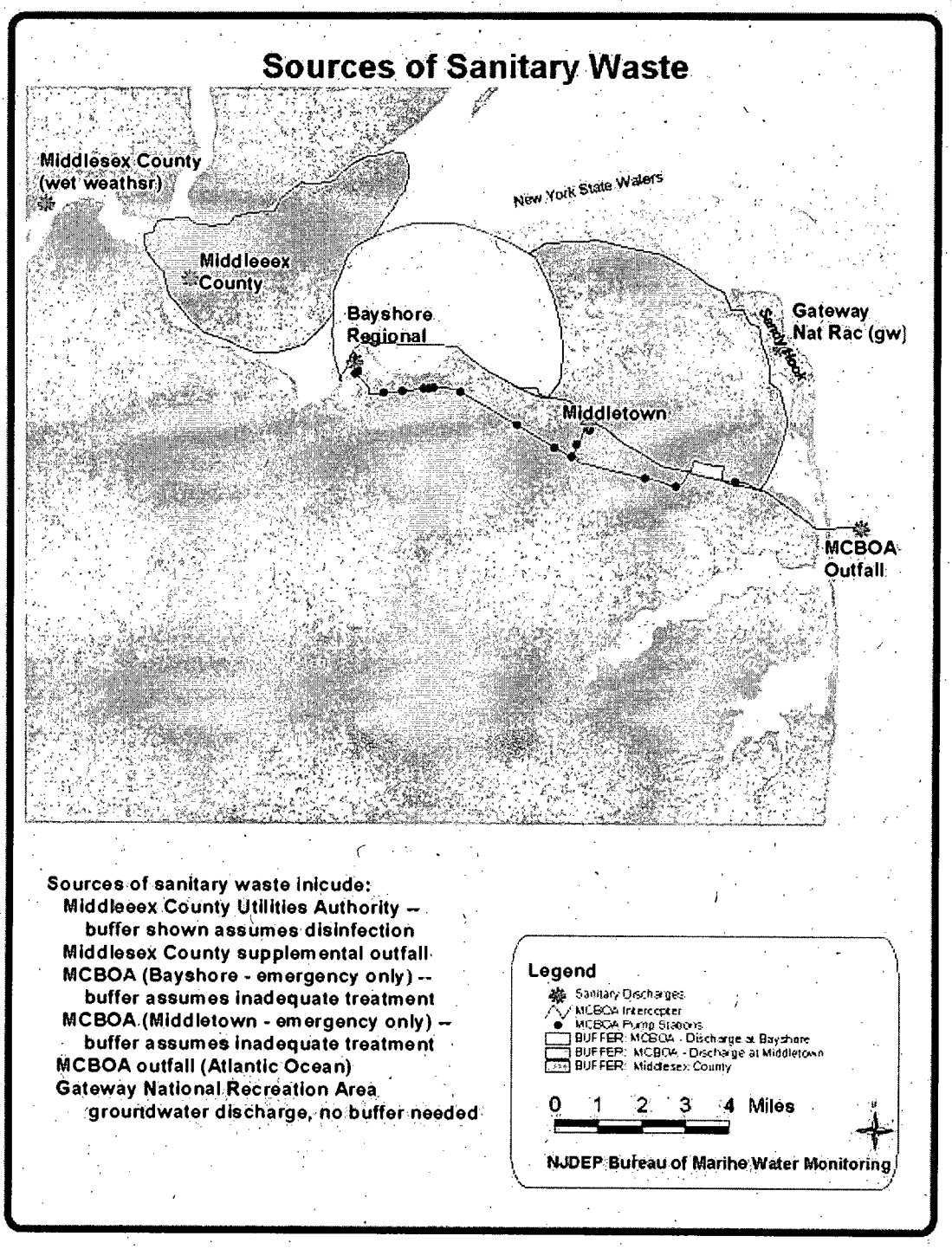



FIGURE 14: DISCHARGES TO SURFACE WATER, SHOWING EXTENT OF OUTFALL BUFFER

Middlesex County Utilities Authority

The Middlesex County facility discharges from an H-shaped diffuser in the western area of Raritan Bay. The discharge rate is variable, with high flows during and after precipitation events. The permitted flow is 160 MGD; flows in excess of 200 MGD have been reported. The Utility also discharges during precipitation events from a supplemental outfall located in the Raritan River. The flow from this outfall may exceed 150 MGD.

It should be noted that Middlesex County uses chlorination to disinfect. Therefore, viral contamination would be minimally affected by treatment processes. In addition, the facility discharges numerous heavy metals that may contribute to potential exceedances of the Surface Water Quality Standards. As a consequence, the current *Prohibited* area extends beyond the boundaries of the buffer zone shown above, which was calculated assuming that the facility is in compliance with permit limitations for pathogens. This report summarizes data for toxicants in shellfish tissue obtained in the western end of Raritan Bay in the Results section regarding toxicants.

This discharge was also evaluated to determine potential impacts in the event that chlorination facilities were to become inoperable. In that case, coliform levels at the boundary of the current *Special Restricted* area would exceed water quality criteria applicable to *Special Restricted* waters in 12-24 hours (depending on ambient temperature and bacterial die-off) after the beginning of the malfunction. (See Figures below.)

In addition, as shown in the Results section regarding coliform levels in the area immediately adjacent to the *Special Restricted* area (north and west of Conaskonk Point), it is apparent that there is a source of coliform bacteria in the western part of the Bay that contributes to mean coliform levels as well as coliform level variability. In spite of this, the stations sampled in the area currently meet *Special Restricted* criteria.

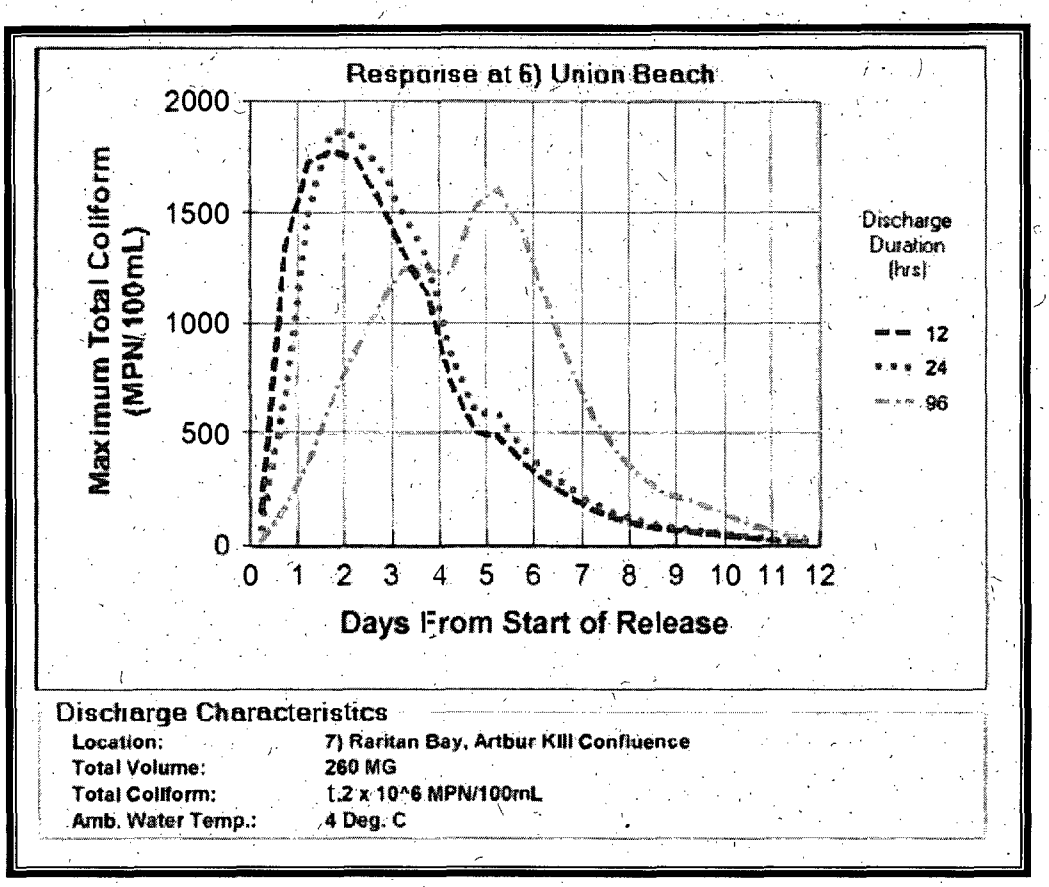



FIGURE 15: TIME OF TRAVEL FOR WINTER DISCHARGE OF UNCHLORINATED EFFLUENT

The blue line indicates anticipated coliform levels at Union Beach if both outfalls are discharging at maximum permitted flow for 24 hours. The green line indicates anticipated coliform levels at Union Beach if the normal outfall located in western Raritan Bay is discharging at maximum permitted flow for 24 hours. The red line indicates coliform levels if the total discharge of 260 MG is spread over a four-day period. This scenario is unlikely. During winter months, when the temperature is low, coliform levels exceeding 500 MPN/100 mL would be anticipated within 12 hours of the beginning of the discharge. During the winter months, clams are relatively inactive and this provides sufficient time to suspend harvest in the area in the event of a chlorination malfunction.

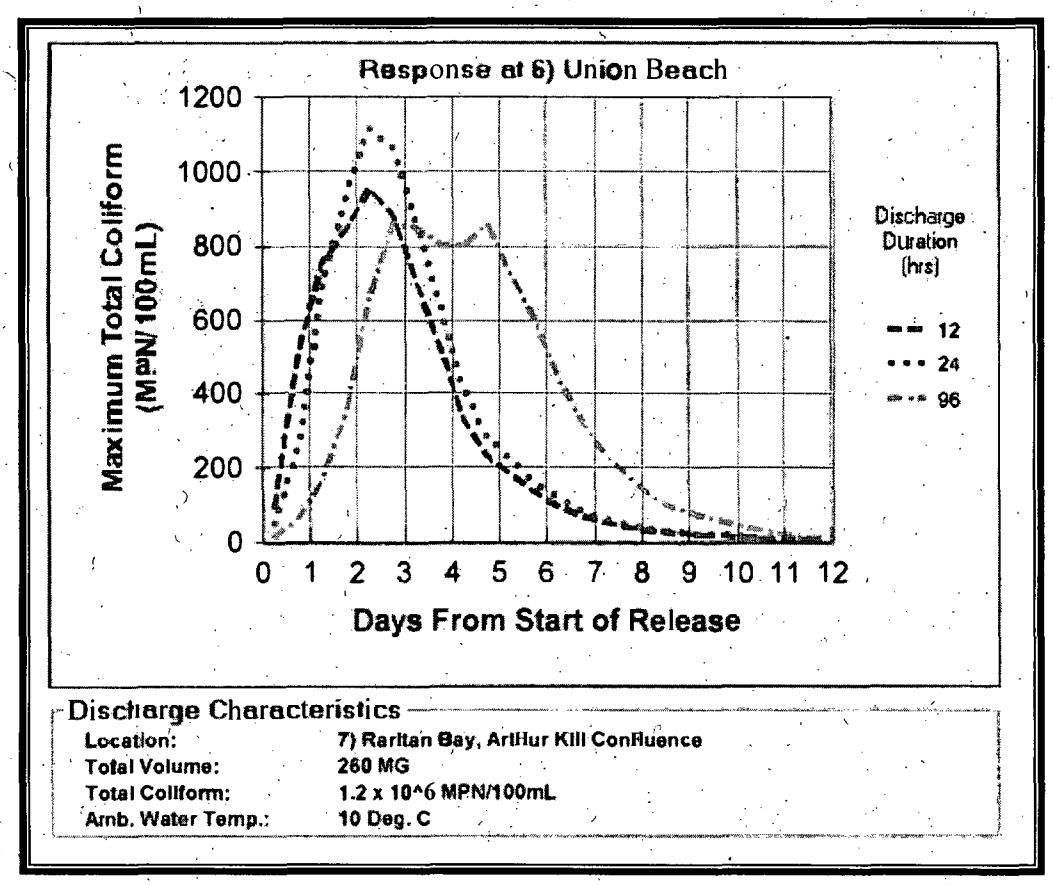



FIGURE 16: TIME OF TRAVEL FOR FALL / SPRING DISCHARGE OF UNCHLORINATED EFFLUENT

The blue line indicates anticipated coliform levels at Union Beach if both outfalls are discharging at maximum permitted flow for 24 hours. The green line indicates anticipated coliform levels at Union Beach if the normal outfall located in western Raritan Bay is discharging at maximum permitted flow for 24 hours. The red line indicates coliform levels if the total discharge of 260 MG is spread over a four-day period. This scenario is unlikely. During winter months, when the temperature is low, coliform levels exceeding 400 MPN/100 mL would be anticipated within 24 hours of the beginning of the discharge. At a temperature of 10°C, the clams are moderately active, but 24 hours is sufficient time to suspend harvest in the event of a chlorination malfunction.

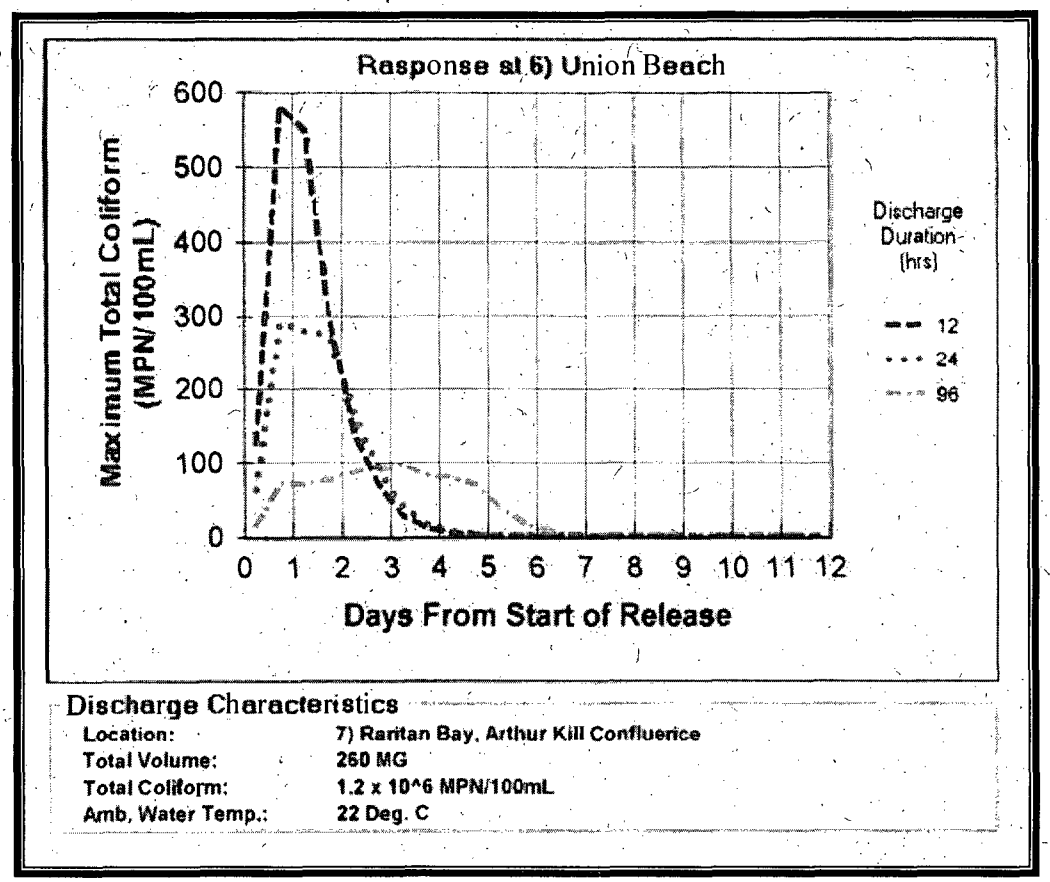



FIGURE 17: TIME OF TRAVEL FOR SUMMER DISCHARGE OF UNCHLORINATED EFFLUENT

The blue line indicates anticipated coliform levels at Union Beach if both outfalls are discharging at maximum permitted flow for 24 hours. The green line indicates anticipated coliform levels at Union Beach if the normal outfall located in western Raritan Bay is discharging at maximum permitted flow for 24 hours. The red line indicates coliform levels if the total discharge of 260 MG is spread over a four-day period. This scenario is unlikely. During winter months, when the temperature is low, coliform levels exceeding 500 MPN/100 mL would be anticipated within 24 hours of the beginning of the discharge.

Monmouth County Bayshore Outfall Authority

MCBOA (a non-profit organizafion) operates the pipeline system to transmit secondary treated effluent from treatment plants in Union Beach (Bayshore Regional Sewage Authority) and Belford (Middletown Sewage Authority) for disposal into the Atlantic Ocean. The pipeline serves 12 municipalities. The communities include Atlantic Highlands, Highlands, Middletown, Holmdel, part of Marlboro and Colts Neck, Union Beach, Hazlet, Keansburg, Matawan Borough, Matawan Township and Keyport.

The pipeline is a force main designed in 1970 to meet the sewage disposal needs of the region to the year 2000 with a design flow for 28 MGD. It is constructed of reinforced concrete pipe and steel. Pump stations located at Union Beach and Belford have large retention basins used to attenuate peak flows and even out daily flow variations. Numerous inspection chambers are provided for adequate maintenance. Emergency pumps and electrical generators are maintained at each pump station. The pipeline is 74,000 feet long and follows the former rail bed of the Central Railroad of New Jersey, extending from Union Beach to a point 4,000 feet into the Atlantic Ocean off Sandy Hook. It passes under Sandy Hook Bay just north of the Highlands Bridge (Figure 13).

In 1973 the Middletown plant began pumping effluent to the line at a rate of five MGD. In 1974 the Union Beach plant began pumping to the line at a rate of two MGD. Both facilities were recently upgraded and expanded to accommodate additional tie-ins. Each presently pumps at the rate of approximately 15-17 MGD under dry weather conditions.

Since the last report in 1999, the pipeline was rehabilitated and repaired. During the repair period, treated effluent was discharged at the treatment facilities located in Belford and Union Beach into Raritan Bay. Since the completion of the rehabilitation project in February 1999, there have been no failures in the pump stations leading to a discharge of effluent into Raritan Bay.

Facilities at Sandy Hook

The National Park Service operates a recently upgraded wastewater treatment facility on park property. The plant handles approximately 150,000 gallons per day. The plant provides tertiary treatment with treated effluent discharged to infiltration beds. The facility is well maintained, with no evidence of overland discharges into the Bay. There are no surface water discharges. All buildings on the National Park property are connected to the sanitary sewer line. A few remote beach areas still use portable toilets during the summer months.

Sanitary wastewater generated at the Coast Guard Station on Sandy Hook is handled by the National Park Service's treatment facility. The Park Service also services the collection lines. Coast Guard vessels have portable toilets or holding tanks. There are no wastewater discharges associated with waterfront activities.

Facilities at the Earle Naval Station

The naval docking facilities at the Earle Naval Pier extend approximately 2 miles into Sandy Hook Bay. There are no discharges from the pier operation or along the adjacent shoreline. Sanitary wastes are pumped from holding tanks on docked ships to a pipeline connected to the Middletown Township facility at Belford. Bilge water from docked ships is pumped to railroad tank cars and transported to an oil-water separator. Processed wastewater then goes to the sanitary line.

International Flavor and Fragrances Facility

The International Flavor and Fragrances plant located between Union Beach and Keansburg, along the eastern side of East Creek is no longer operated as a manufacturing facility. The company now uses it as a warehouse. The small amount of wastewater now generated goes directly to the sanitary sewer line and then to the wastewater treatment plant. Shellfish waters at the mouth of East Creek are classified as *Prohibited* waters.

## *BUFFERS AROUND OUTFALLS*

The National Shellfish Sanitation Program requires establishment of *Prohibited* areas adjacent to outfalls from domestic sewage treatment facilities. The *Prohibited* area ensures that pathogens will not contaminate the resource used for human consumption. The size of the *Prohibited* buffer zone must consider the following characteristics:

- ? Pollution Conditions
- ? Flow rate, treatment facility performance, location of the shellfish resource
- ? Dispersion, dilution, and time of travel
- ? Current velocity and net transport velocity; volume of water; depth of receiving water; direction of travel; stratification; location of discharge; tidal characteristics; receiving water geometry
- ? Pathogen die-off rate
- ? Bacteriological quality required in adjacent waters
- ? Adjacent harvest use classifications
- ? Identifiable landmarks

These factors account for the presence of contaminants in the effluent, the water quality that must be maintained to protect human health, and the relative dispersion available in the vicinity of the outfall.

Calculated buffer zones for the permitted discharge from Middlesex County Utilities Authority located at the western end of Raritan Bay and the overflow points for Monmouth County Bayshore Outfall Authority are shown in Figure 13 and discussed below. The buffer zone for Middlesex County Outfall Authority is based on the effluent plume study completed by the Authority as a condition of the NJPDES permit. While discharges from the MCBOA overflow points occurred frequently prior to the rehabilitation project completed In 1999, there have been no significant discharges reported since the completion of the repair project.

Contaminants

Effluent from wastewater treatment facilities contains a variety of contaminants. Historically, the emphasis of the shellfish program has focused on bacteriological contamination. Indicator organisms (usually coliform bacteria) are used to assess the likelihood of pathogen contamination. While these indicator

organisms are not in themselves pathogenic, or disease-producing, they are found in human waste in similar numbers to organisms that can cause disease. Disinfection processes such as chlorination kill these bacteria.

Wastewater treatment facility effluent may also include viral particles. Viruses are usually not killed by chlorination. Effluent may also contain various toxicants, such as heavy metals or other contaminants. While some of these toxicants may be partially removed by conventional treatment, other contaminants remain in the effluent discharged to the receiving water.

Size of the Buffer Zone

The level of treatment and the specific treatment processes provided by the wastewater facility affect the size of the *Prohibited* zone established in the vicinity of the outfall. If disinfection is provided by chlorination, the size is adjusted to account for:

- The reliability record of the particular facility based on data submitted by the facility, and
- The likelihood of viral contamination, which is unaffected by chlorination.

The *Prohibited* area is also adjusted to allow for dispersion of contaminated water in the event that the disinfection process at the facility becomes inoperable. Thus the area could be adjusted based on factors such as installation of alarm systems and/or round-the-clock staffing at the facility.

Middlesex County Utilities Authority

The Middlesex County facility discharges from an H-shaped diffuser in the western area of Raritan Bay. The discharge rate is variable, with high flows during and after precipitation events. The permitted flow is 160 MGD; flows in excess of 200 MGD have frequently been reported. The Utility also discharges during precipitation events from a supplemental outfall located in the Raritan River.

In 1989 the Utilities Authority completed an effluent plume study as a condition of the NJPDES permit issued to the facility. The study consisted of a dye study and computer modeling. Based on that study, the effluent is rapidly diluted by a factor of approximately 15 due to buoyant mixing at the outfall location. Subsequent to that initial dilution, the plume moves to the southeast in the dominant ebb-tide current with minimal additional dilution due to dispersion. Since the primary ebb current then moves toward the northeast, it appears that the effluent plume moves primarily in the vicinity of the major shipping channel where the water is deeper and the current is stronger. However, as can be seen from the hydrographic information, the circulation in Raritan Bay is not straightforward and the concomitant mixing and dilution of the effluent is accordingly complex.

The study completed by Middlesex County Utilities Authority extended only for a short distance beyond the outfall.

Figure 14 shows the area of the study and the best estimate of the Bureau of Marine Water Monitoring of the area impacted by the Middlesex County effluent plume under normal operating conditions.

It should be noted that Middlesex County uses chlorination to disinfect. Therefore, viral contamination would be minimally affected by treatment processes. In addition, the facility discharges numerous heavy metals with the potential to cause exceedances of the Surface Water Quality Standards.

Monmouth County Bayshore Outfall Authority

Domestic waste treated at the Bayshore Utilities Authority in Union Beach and at the Middletown Sewerage Authority in Belford is discharged to the Monmouth County Bayshore Outfall Authority and then conveyed to a permitted outfall in the Atlantic Ocean. The permitted outfall is located approximately 1 mile offshore. The interceptor owned by the Outfall Authority was constructed between 1970-1973. Significant rehabilitafion of the line was completed in 1999.

In the event of an unpermitted discharge at either Belmar or Union Beach, shellfish harvesting is suspended in Raritan Bay. The extent of the affected shellfish beds is shown in Figure 13. Some beds are closed if the discharge occurs in the Union Beach vicinity; others are closed if the discharge occurs in the Belford vicinity. The extent of the area affected is dependent on the following variables:

- The known variability of effluent bacteriological quality (based on effluent data submitted by the facility as a part of Discharge Monitoring Reports),
- The volume of effluent,
- Prevailing wind direction and velocity during the time of the discharge,
- The depth of the receiving water, and
- The tidal currents.

## *STORMWATER DISCHARGE*

Numerous storm water outfalls have been mapped in this area. Most of the storm water discharges to creeks. Some outfalls discharge directly into the Raritan and Sandy Hook Bays. Although stormwater runoff influences water quality in Raritan and Sandy Hook Bays, the estuaries (particularly Raritan Bay) are also influenced by numerous other waterways and discharges from outside the growing area. Raritan Bay can also be influenced by Sandy Hook Bay since the net flow is outward into the Raritan Bay and Lower New York Harbor .

Street flooding in the communities of Keansburg, Union Beach, Middletown and Hazlet is alleviated by the Bayshore Floodgate. This floodgate is located at the junction of Thorns Creek and Waackaack Creek. This flood control project consists of a 50 ton dam that can be closed to prevent high tides of the Raritan Bay from flooding low-lying areas. Three to four miles of earthen

berms were constructed to work in conjunction with the floodgate. Four diesel pumps each capable of 200 gallons per minute can be used to lower water levels behind the dam. The communities mentioned above all divert their stormwater discharges into the two creeks. The facility is operated by the New Jersey Department of Environmental Protection. The facility uses a septic system to handle their wastewater. No problems are reported with the operation of this septic system. Shellfish waters at the mouth of the Waackaack Creek are classified as *Prohibited* waters.

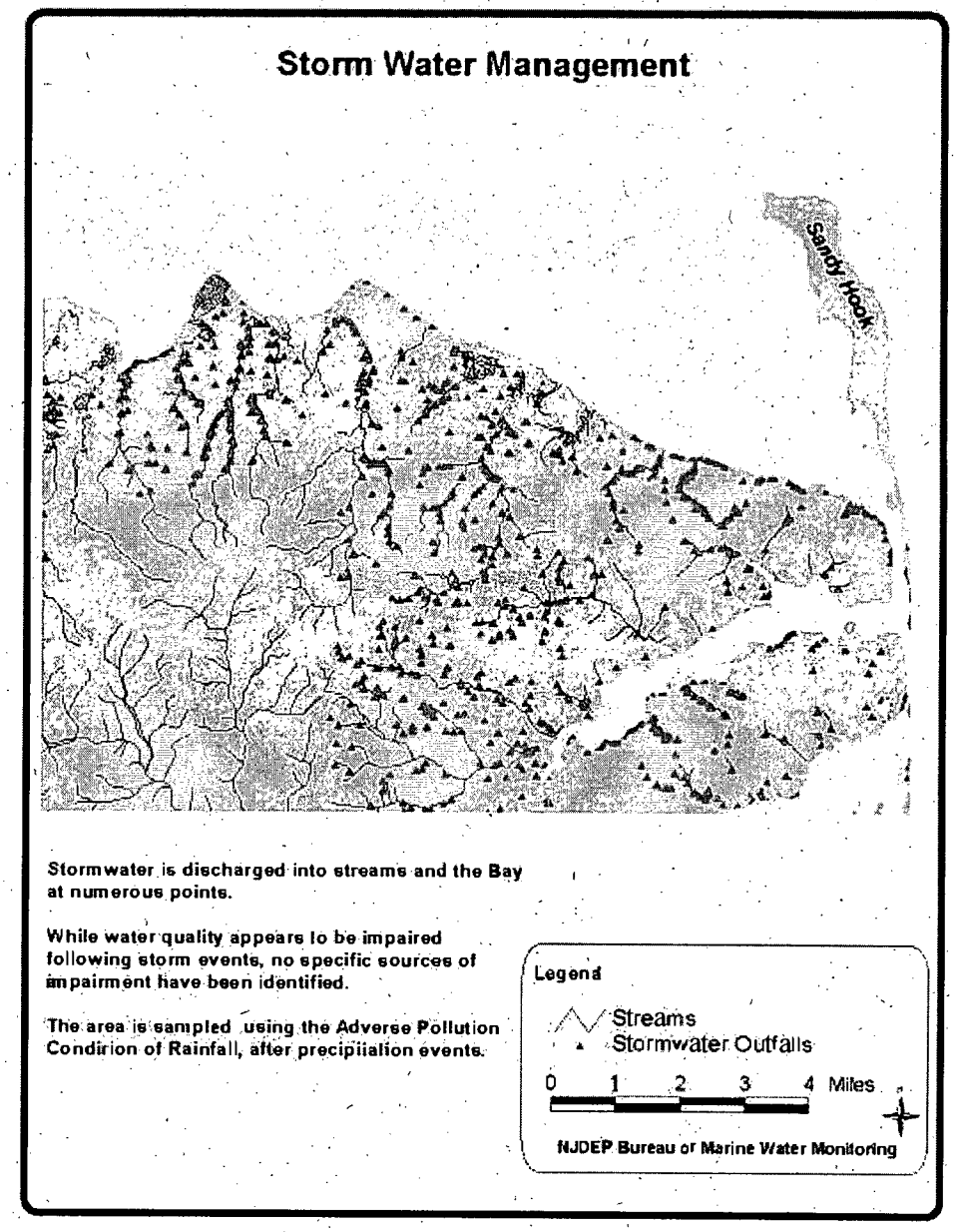
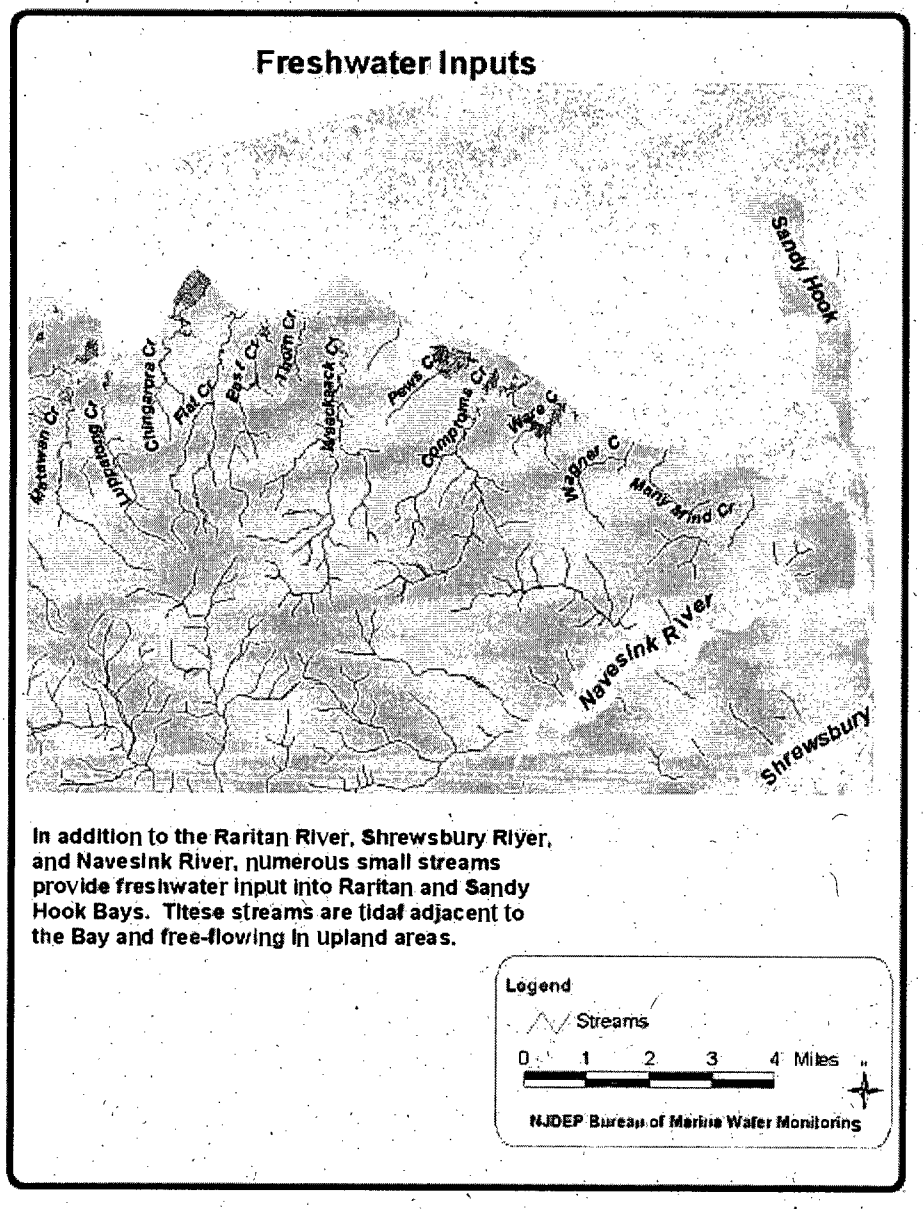



FIGURE 18: STORM WATER OUTFALL LOCATIONS

## *INPUT FROM SURFACE WATER DRAINAGE*

There are 11 creeks that are located between Conaskonk Point and Highlands that discharge directly to the *Special Restricted* waters of Raritan / Sandy Hook Bay. From west to east the creeks are named as follows; Chingarora Creek (ditched extension), Flat Creek (Union Beach), East Creek, Thorns Creek, Waackaack Creek, un-named creek (Keansburg), Pews Creek (Ideal Beach), Compton Creek (Belford Harbor), Ware Creek (Earle Pier), Wagner Creek (Leonardo), Many Mind Creek (Atlantic Highlands). All of these streams can be considered as minor tributaries to the bay waters. Each of them receives stormwater runoff from areas located to the north and south of Route 36.




The Bureau of Marine Water Monitoring samples the bay waters near the mouths of several of these creeks. (The sampling stations were added in 1999.) There is insufficient data for evaluation at this time.

**FIGURE 19:**
**FRESHWATER INPUTS TO RARITAN / SANDY HOOK BAYS**

## *INDIRECT DISCHARGES*

There are numerous other potential sources of contamination, primarily from various sites identified for remediation procedures. Most of these are gasoline service stations located at some distance from the Bay that have had leakage of petroleum products into the soil surrounding storage tanks. There is no evidence that these products have reached the bay or that they have significantly impacted shellfish resources in the Bay.

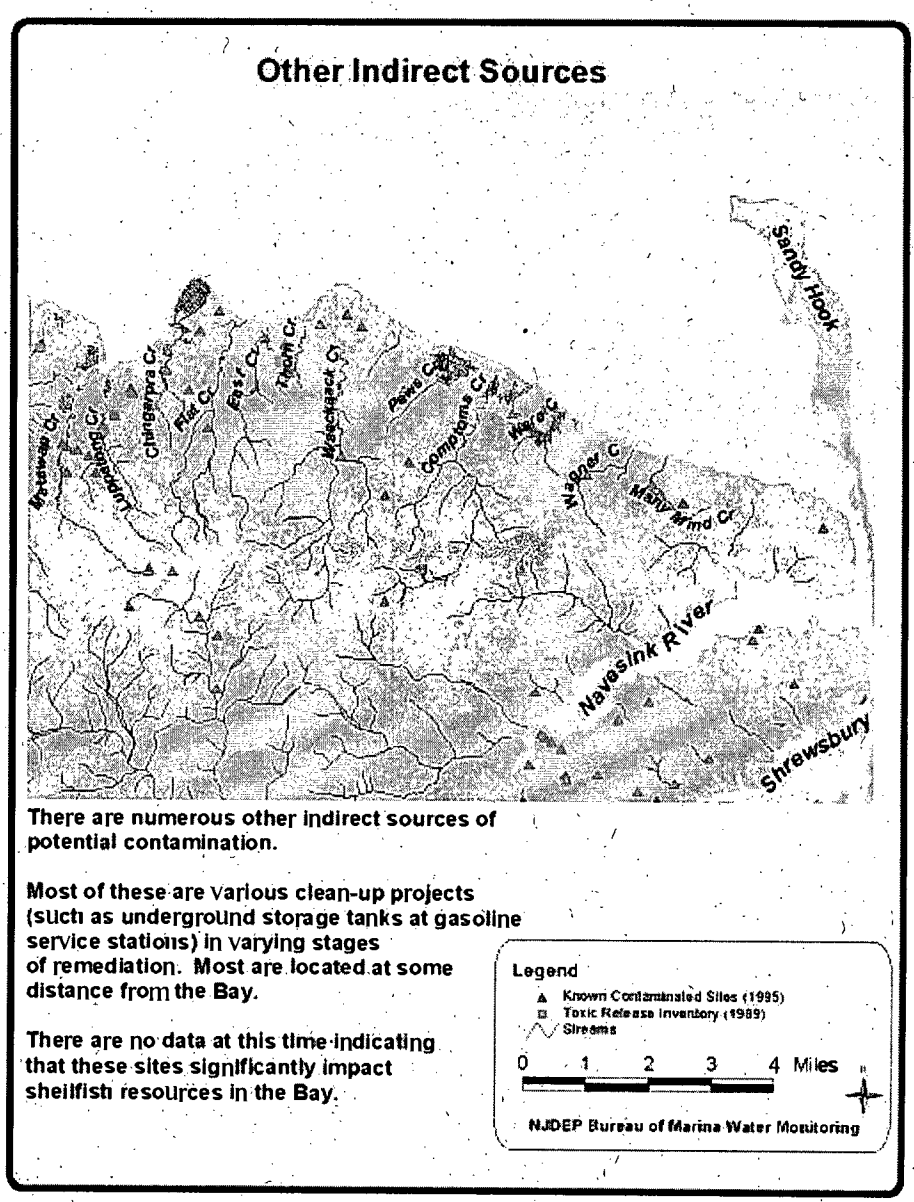



FIGURE 20: INDIRECT DISCHARGES

## *MARINAS*

Marina facilities have the potential to affect the suitability of shellfish growing areas for the harvest of shellfish. The biological and chemical contamination associated with marina facilities may be of public health significance. New Jersey defines a marina as "any structure (docks, piers, bulkheads, floating docks, etc.) that supports five or more boats, built on or near the water, which is utilized for docking, storing, or otherwise mooring vessels and usually but not necessarily provides services to vessels such as repairing, fueling, security or other related activities" and designates the confines of the marina as *Prohibited* for the harvest of shellfish. Adjacent waters are classified using a dilution analysis formula.

It is recognized by the NSSP *Guide for the Control of Molluscan Shellfish,* 1997, that there are significant regional differences in all factors that affect marina pollutant loading. The manual therefore allows each state latitude in applying specified occupancy and discharge rates. The NSSP guidelines assume the worst case scenario for each factor.

$$BufferRadius(ft) = \sqrt{\frac{2x10^{9}(FC/person/day)x2(person/boat)x[(.25slips > 24') + (0.065 > slips > 24')]x2}{140000(FC/M^{3})xdepth(ft)x0.3048(M/ft)x2(tides/day)}}x3.28(ft/M)$$

**EQUATION 1 :MARINA BUFFER EQUATION. (ADAPTED FROM FDA. 1989):**

Explanation of terms in equation:

| | |
|---|---|
| Fecal coliform per person per day: | $2 \times 10^{9}$ |
| Number of people per boat: | 2 |
| For slips able to accommodate boats > 24 feet (combination of factors yields multiplier of 0.25): | |
| Number of slips occupied: | 50% |
| Number of boats occupied: | 50% |
| For boats < 24': | 6.5% discharge waste |
| Angle of shoreline: | 180°, which results in factor of 2 |
| Number of tides per day: | 2 |
| Depth in meters: | depth in feet x conversion factor |
| Water quality to be achieved: | 140000 FC/meter $^{3}$ |
| Convert meters to feet: | 3.28 |

Marina buffer zones may be calculated using the formula above, or may be determined using a dilution analysis computer program developed by the State of Virginia and the USFDA. The formula above considers only dilution and occupancy rates. The computer program, which is used for complex configurations where the formula is unlikely to provide the needed accuracy, also considers tidal exchange and bacterial die-off.

There are 28 marinas adjoining the Raritan and Sandy Hook Bays, as shown in Table 6. The marinas are located on the southern shore of the Bay. The waters enclosed by the marina are classified as *Prohibited*; depending on the size of the marina and the water quality, water immediately adjacent to each marina may be classified as *Prohibited*, *Special Restricted*, or *Seasonally Approved* (no harvest during summer months when the marina is

active). Marina buffer zones were calculated using the formula given above. The size of each buffer zone is shown in the table below.

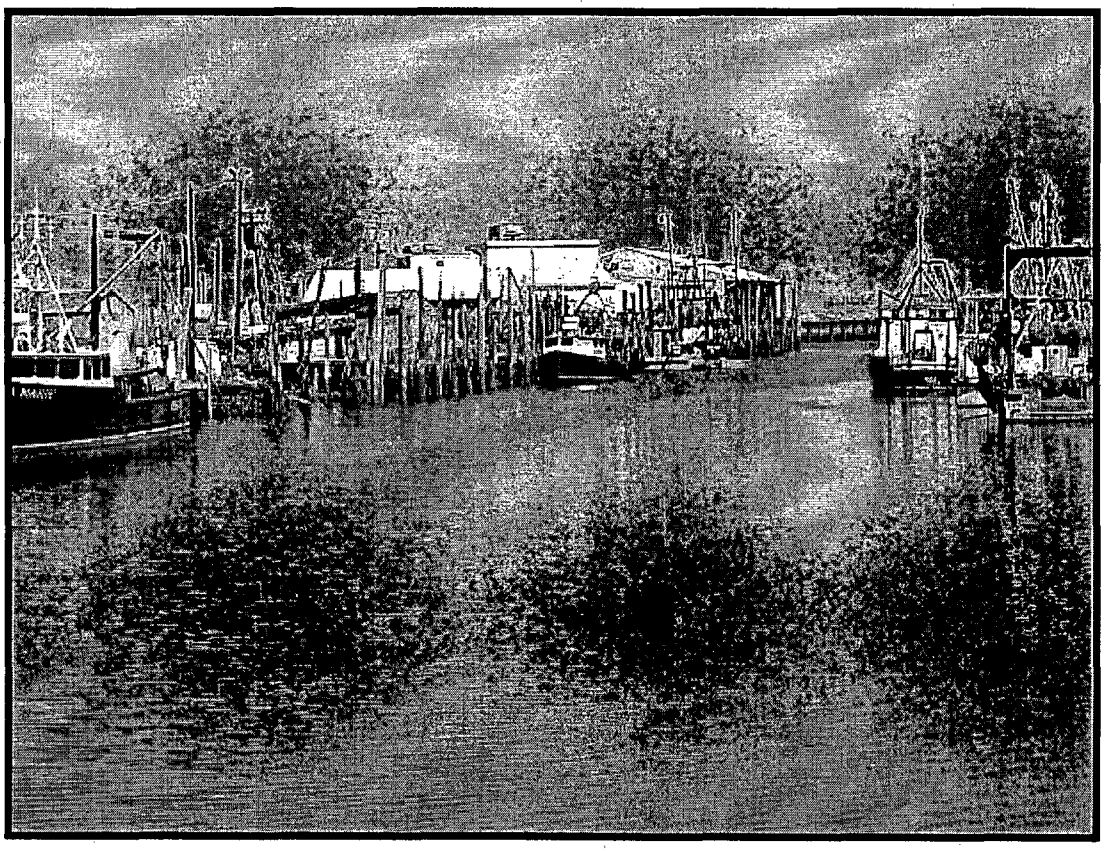


FIGURE 21: BOAT BASIN AT BELFORD

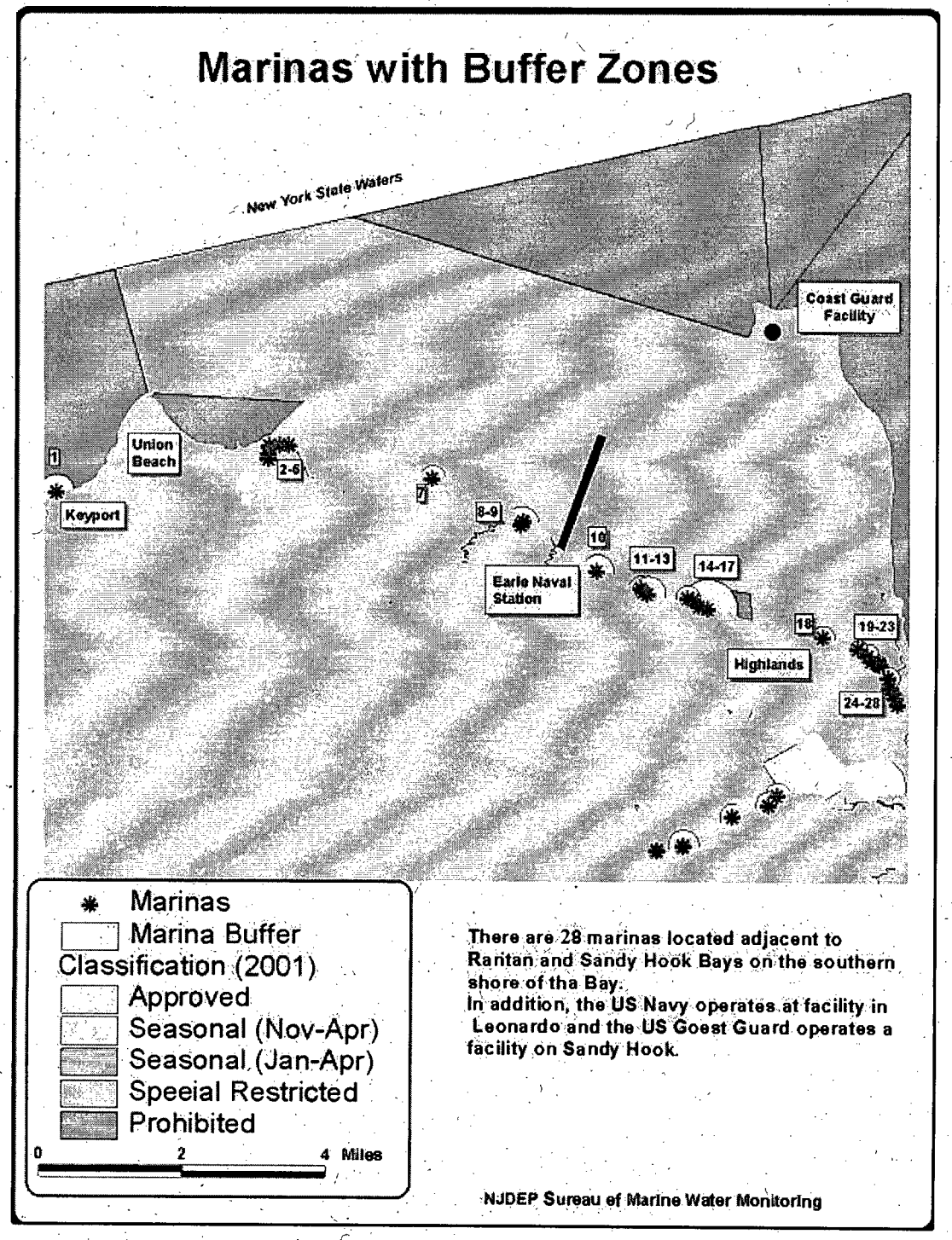



FIGURE 22 : MARINA FACILITIES LOCATED IN RARITAN AND SANDY HOOK BAYS

TABLE 6: MARINAS LOCATED IN THE RARITAN / SANDY HOOK BAYS

| MAP KEY | MARINA | NUMBER OF SLIPS | BUFFER ZONE (ft) |
|---|---|---|---|
| 1 | Keyport Public Dock | 100 (est) | 1267 |
| 2 | Captains Cove Marina | 45 | 595 |
| 3 | Braun's Landing | 14 | 344 |
| 4 | Lentz Marina | 50 (est) | 818 |
| 5 | Waackaack Marina | 82 | 730 |
| 6 | Abandoned, Waackaack Cr | 0 | 0 |
| 7 | Monmouth Cove Marina, (County) | 127 | 942 |
| 8 | Middletown Public Dock | 100 (est) | 1267 |
| 9 | Belford Commercial Fishing Fleet | 10 (est) | 366 |
| 10 | Leonardo State Marina | 179 | 1151 |
| 11 | Wagners | 50 (est) | 896 |
| 12 | Sandy Hook Catamaran Club | 50 (est) | 457 |
| 13 | Blackfoot | 100 (est) | 896 |
| 14 | Skips Place | 50 (est) | 896 |
| 15 | Atlantic Highlands Bait & Tackle | 16 | 236 |
| 16 | Atlantic Highlands Yacht Club | 50 (est) | 896 |
| 17 | Atlantic Highlands Municipal Marina | 518 | 2134 |
| 18 | Sandy Hook Bay Marina | 85 | 832 |
| 19 | Captains Cove | 25 (est) | 634 |
| 20 | Marina on the Bay | 85 | 832 |
| 21 | Clam Hut Restaurant | 24 | 450 |
| 22 | Highlands Condo | 18 | 250 |
| 23 | Schute Sea Tow | 22 | 250 |
| 24 | Cottrell's | 50 (est) | 818 |
| 25 | Gateway Marina | 154 | 1270 |
| 26 | Schupp's Landing | 38 | 432 |
| 27 | Bahr's Landing/COZ Seas Marina | 30 | 500 |
| 28 | Moby's | 20 | 300 |

## *DREDGING PROJECTS*

There are numerous dredging projects proposed by the Corps of Engineers (COE) in the Port Newark, Newark Bay, Hackensack River, Raritan River Channel, Arthur Kill, Kill Van Kull, and Port Jersey areas. The Corps has proposed locating a dredge spoils site in New York State waters (adjacent to New Jersey waters) at Flynn's Knoll.

## *LANDFILLS*

Two closed landfills are located along the shoreline in Keyport and Belford. Both landfills extend to the shoreline of the bays. Both landfills appear to occupy areas formerly covered by wetlands and tidal marsh deposits. The elevation of each landfill is approximately 10 feet above sea level. The landfill in Keyport operated under the name of WDI . This was a private landfill that was closed in 1979. The landfill located in Belford, Middletown Township was also a private landfill that closed in 1977. Monmouth County currently owns it and intends to develop the property into a ferry site. No problems have been reported at either landfill that would impact marine water quality (Chojnacki, 1998). Groundwater sampling from the landfills is not required because they closed prior to 1982.

## *OTHER POTENTIAL INPUTS*

A coal gasification plant was located along the banks of Many Mind Creek in Atlantic Highlands many years ago. The environmental impact (if any) of this abandoned site on the marine waters of Sandy Hook Bay and shellfish resources of the area is unknown. It should be noted that the New Jersey Department of Environmental Protection Site Remediation Program has not verified that any known or abandoned contaminated waste sites directly impact the marine waters or the shellfish resources of the Bay.

There are numerous identified sites listed as "Known Contaminated Sites" or "Toxic Release Inventory Sites". However, there is no evidence to indicate that any of these sites adversely impact the shellfish waters at this time. Likewise, the identified discharges to ground water are not located adjacent to the Bay and there is no evidence that any of those permitted discharges adversely impact shellfish waters at this time.

The area is not adversely impacted by agricultural practices, livestock or wildlife populations.

## *SPILLS OR OTHER UNPERMITTED DISCHARGES*

There have been no significant unpermitted discharges in this area since the MCBOA pipeline was rehabilitated in 1999.

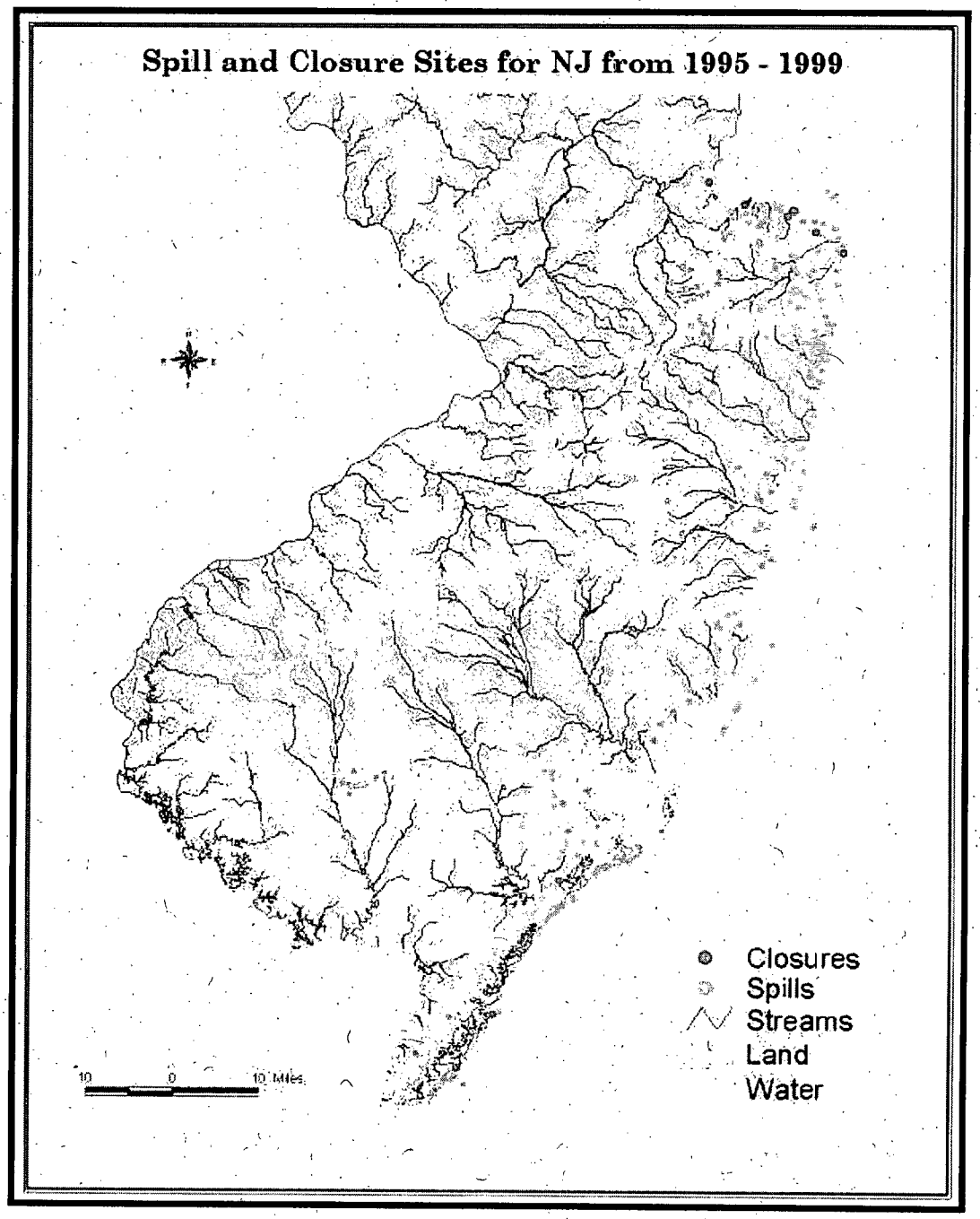



**FIGURE 23: SPILLS OR OTHER UNPERMITTED DISCHARGES (STATEWIDE, 1995-1999)**

## CIRCULATION

Hydrographic studies have found that the mixing of fresh water from Raritan River and saltwater from lower bay creates a large, slow moving counter-clockwise circulation pattern with much back-and-forth movement within Raritan Bay. Fresh water entering the bay from the Raritan River has a net movement toward the ocean of about 500 yards a day. Therefore, it takes 16 to 21 days for the bay to flush itself (Bennett, 1983). Tidal action represents a major influence in the distribution of pollutants in the estuary, with a mean tidal range of 1.5 meters (5 feet). Tidal current and flow velocity charts for the New York Harbor area, including Raritan and Sandy Hook Bays, are depicted in the following figures published by the U.S. Department of Commerce (NOAA, 1956).

The primary flow pattern from the mouth of the Raritan River toward the Atlantic Ocean is southeast toward Union Beach and then to the northeast along the southern edge of Staten Island. This flow pattern roughly follows the established shipping channel.

The primary flow pattern from the Shrewsbury and Navesink Rivers is from the mouth of the Shrewsbury near Highlands in the northwesterly direction somewhat parallel to the southern edge of Sandy Hook Bay and then along the western edge of Sandy Hook.

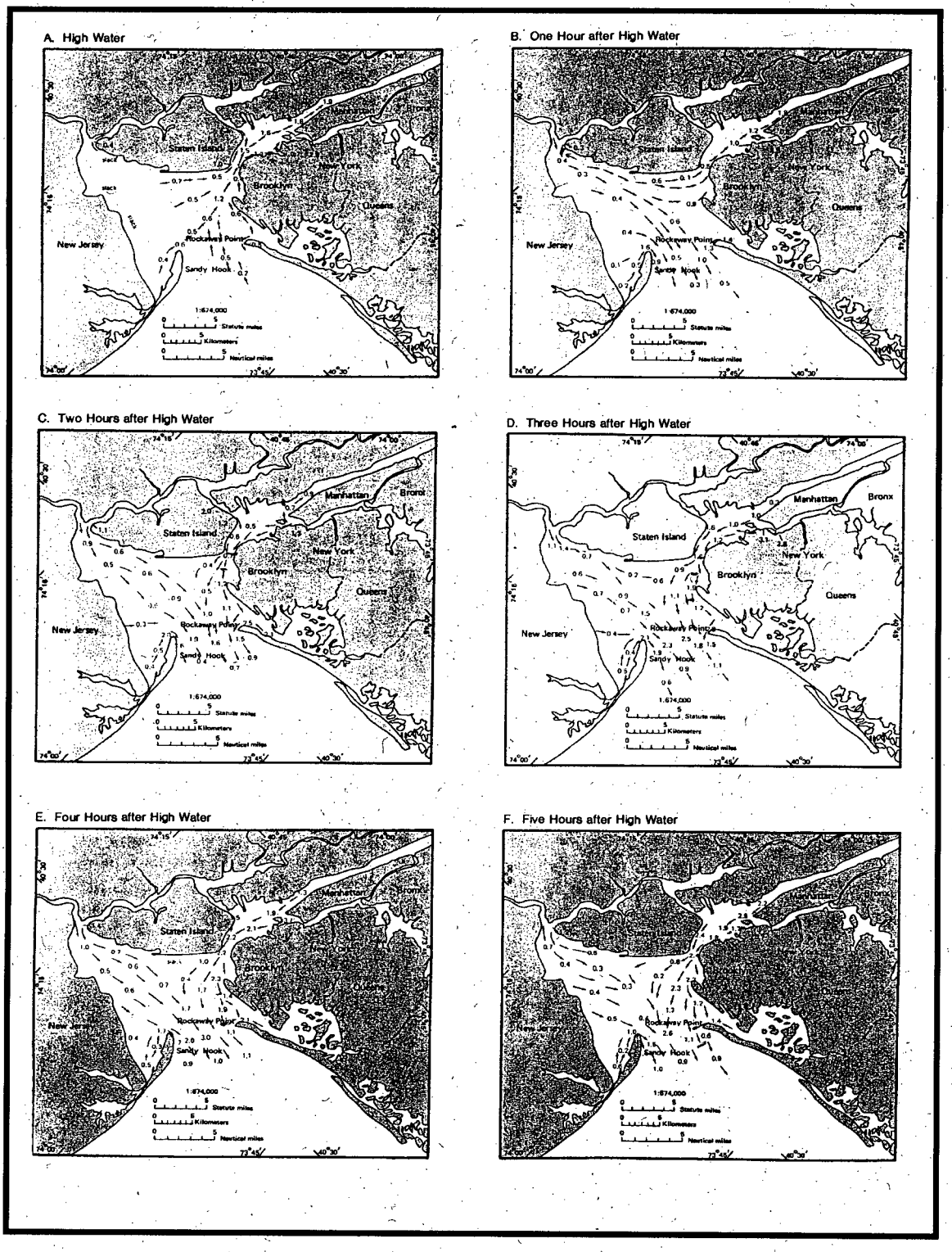



FIGURE 24: TIDAL CURRENTS DURING EBB TIDE

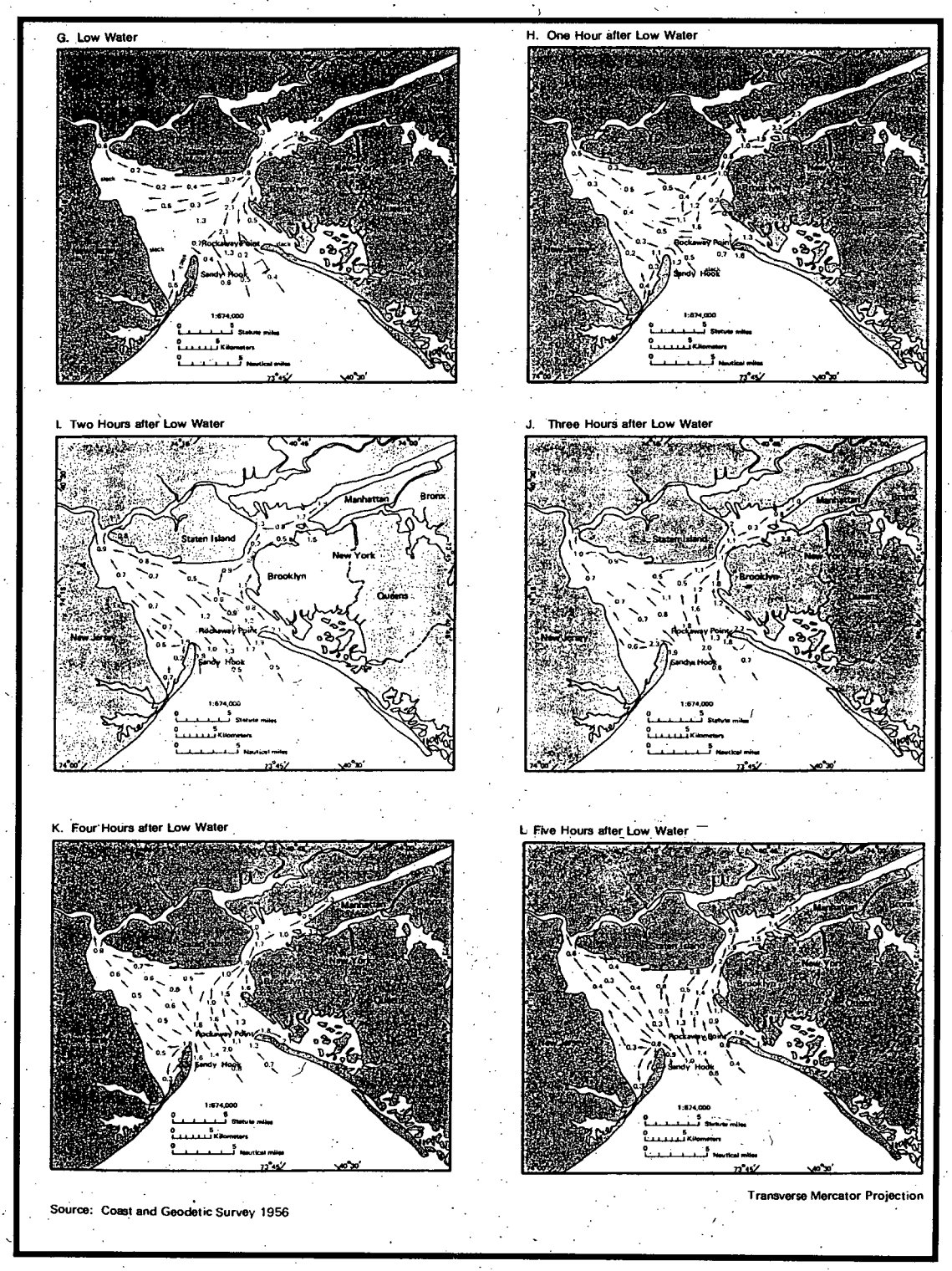



FIGURE 25: TIDAL CURRENTS DURING FLOOD TIDE

## PATTERNS OF PRECIPITATION

Precipitation patterns in the coastal areas of New Jersey are typical of the Mid-Atlantic coastal region. Typical summer storms are localized storms associated with thunderstorms. Winter storms are frequently associated with northeasters. Hurricanes can occur during the summer and early fall.

| | |
|---|---|
| Annual Average Number of Storms | 60 |
| Average Storm Event Duration | 10 hours |
| Average Storm Event Intensity | 0.08 – 0.09 inches/hour |
| Average Storm Event Volume | 0.65 inches |

TABLE 7: AVERAGE MID-ATLANTIC STORM EVENT INFORMATION. SOURCES: USEPA; US DEPARTMENT OF COMMERCE

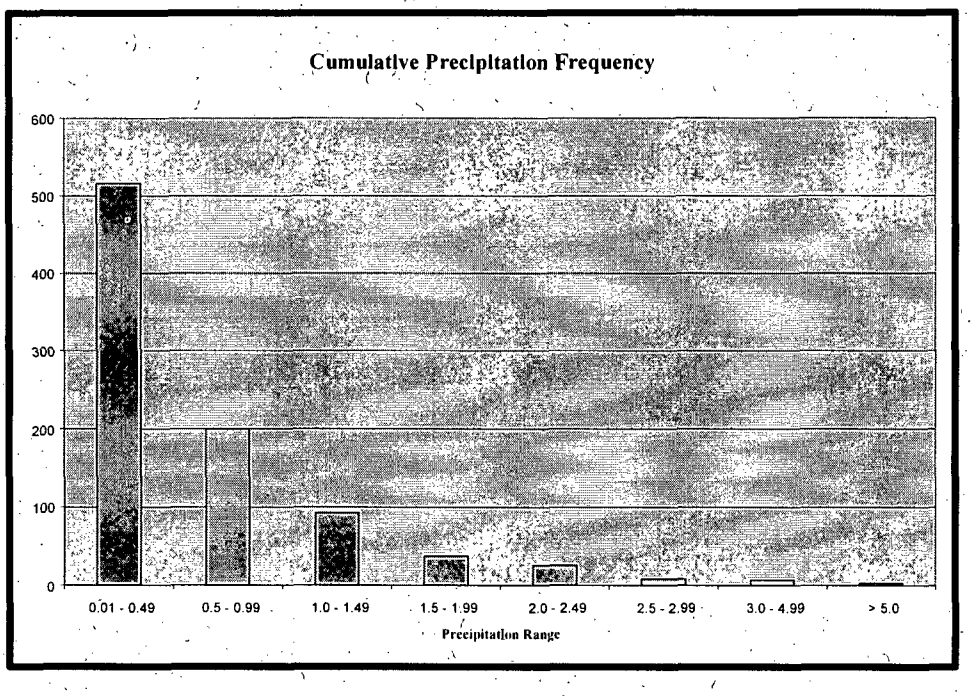
Although the average storm event lasts approximately 10 hours, with an accumulation of 0.65 inches, it is not unusual for an individual storm volume to be 2 – 3 inches. Note the data below that shows the 2-year return for a 6-hour storm event to be between two and three inches, while the 2-year 24-hour return volume varies between three and 4 inches. Storm volumes greater than approximately 3.5 – 4.0 inches are much less frequent.

TABLE 8: STORM EVENT VOLUME FOR 2-YEAR STORM EVENT RECURRENCE (SOURCE: USGS)

| Location | 2-Year, 1-Hour Rainfall | 2-Year, 6-Hour Rainfall | 2-Year, 24-Hour Rainfall |
|---|---|---|---|
| Millville | 1.33 | 2.33 | 3.02 |
| Cape May | 1.33 | 2.41 | 3.10 |
| Atlantic City | 1.47 | 2.67 | 3.65 |
| Long Branch | 1.55 | 3.02 | 4.15 |
| Newark | 1.21 | 2.34 | 3.25 |
| Sandy Hook | 1.37 | 2.73 | 3.68 |

The duration and volume of storm events can also be depicted as frequency histograms. This graphical depiction (shown below for 1981-1997) provides insight into the frequency for storm events of a given size or duration.

FIGURE 26: STORM EVENT FREQUENCY HISTOGRAM (1981-1997) (SOURCE: NOAA CLIMATIC DATA)




## PRECIPITATION

Precipitation records for the period covered by this report are shown below. There have been no significant changes in hydrography since the last report. The primary weather station is Sandy Hook. The secondary weather station is Newark International Airport. The secondary station is used when data from the primary station is incomplete. Since 1995, the primary station has been Newark. For the period of time covered by this report approximately 50% of the rainfall data was from Newark International Airport.

Normally, the Bureau determines if sampling stations show increasing MPN values with rainfall using an analysis of correlation coefficients. Correlation analysis looks at paired observations (total coliform MPN and rainfall amounts) and assesses whether, on average, one variable increases or decreases as the other variable increases.

Evaluation of rainfall data for the period of time covered by this report does not show an increase in MPN values with increasing rainfall within 48 hours prior to sampling.

However, since all samples were obtained after rainfall, (i.e., there were no dry weather samples), it is unlikely that a significant correlation between precipitation and coliform MPN value would be found. Typically, such a correlation can be demonstrated only when samples are obtained under varying conditions, including dry weather, after storms of low intensity and/or duration, and after storms of high intensity and/or duration.

TABLE 9: CLIMATOLOGICAL DATA

| Sampling Date | RAINFALL AMOUNT | | | NOAA WSO Station Number |
|---|---|---|---|---|
| | Day of Sampling | Day of Sampling + Day Before | Day of Sampling + 2 Days Before | |
| 5/8/1997 | 0 | 0.2 | 0.28 | 7865 |
| 8/26/1997 | 0 | 0 | 0 | 7865 |
| 2/19/1998 | 0 | 0 | 0 | 7865 |
| 2/26/1998 | 0 | 0 | 0.23 | 7865 |
| 3/10/1998 | 0 | 0.13 | 3.08 | 7865 |
| 3/16/1998 | 0 | 0 | 0.11 | 7865 |
| 3/23/1998 | 0 | 0.04 | 0.39 | 7865 |
| 4/3/1998 | 0 | 0 | 0.47 | 7865 |
| 6/24/1998 | 0 | 0.03 | 0.035 | 7865 |
| 1/19/1999 | 1.17 | 1.34 | 1.34 | 7865 |
| 1/20/1999 | 0 | 1.17 | 1.34 | 7865 |
| 1/26/1999 | 0.1 | 0.99 | 0.99 | 7865 |
| 3/2/1999 | 0 | 0 | 0 | 7865 |
| 3/30/1999 | 0 | 0 | 0 | 7865 |
| 5/25/1999 | 0.95 | 1.08 | 1.2 | 7865 |
| 6/15/1999 | 0 | 0 | 0.05 | 7865 |
| 6/22/1999 | 0.18 | 0.71 | 0.71 | 7865 |
| 7/20/1999 | 0.35 | 0.35 | 0.35 | 7865 |
| 3/1/2000 | 0 | 0 | 0.08 | 7865 |
| 3/23/2000 | | | | 7865 |
| 3/29/2000 | | | | 7865 |
| 6/8/2000 | | | | 7865 |
| 7/27/2000 | 0.14 | 3.11 | 3.96 | 7865 |

# *WATER QUALITY STUDIES*

## SAMPLING STATIONS

A total of 632 water samples (261 in the summer and 371 in the winter) from 51 stations were analyzed for total coliform (TC) and fecal coliform (FC) bacteria during the period May 1, 1997 through October 1, 2000. This period was selected to provide a minimum of 15 data points for a year-round analysis. The United States Environmental Protection Agency (USEPA) and the Interstate Sanitation Commission (ISC) provided valuable assistance in sample analysis and sample collection. The ISC performed numerous sampling runs for this report. Samples are collected under the adverse pollution condition of rainfall.

## BACTERIOLOGICAL QUALITY

### *COMPLIANCE WITH NSSP CRITERIA*

Most sampling stations, except for those located in the eastern portion of Sandy Hook Bay exceed approved criteria. There are several stations located to the north and west of the area currently classified as *Special Restricted* where insufficient data have been collected to use for classification. However, data from those stations are consistent with the *Special Restricted* classification and generally exceed the *Approved* criteria.

All sampling stations comply with the NSSP *Special Restricted* criteria.

A similar pattern can be seen for winter data, although there are numerous sampling stations with insufficient data to evaluate for classification. Water quality is generally best in the eastern portion of Sandy Hook Bay, adjacent to Sandy Hook. It should be noted that this area seems to be well-flushed, as the primary ebb flow pattern from the Navesink and Shrewsbury Rivers is along the western edge of Sandy Hook.

Based on these data, it may be possible in the future to upgrade an area in the eastern portion of Sandy Hook Bay to *Seasonally Approved* after additional data are collected during the winter after rainfall.

Based on these data, the primary source(s) of coliform contamination in the Raritan and Sandy Hook Bays appears to be located in the western area of Raritan Bay. (See the figures below depicting the data as interpolated surfaces.) This pattern is evident in the concentration data, both year-round and seasonal, as well as in the data variability. Note that stations located in western Raritan Bay and some portions of Flynn's Knoll had insufficient data to evaluate for compliance. Data from Flynn's Knoll and the area immediately

to the west of Conaskonk Point were consistent with the *Special Restricted* classification.

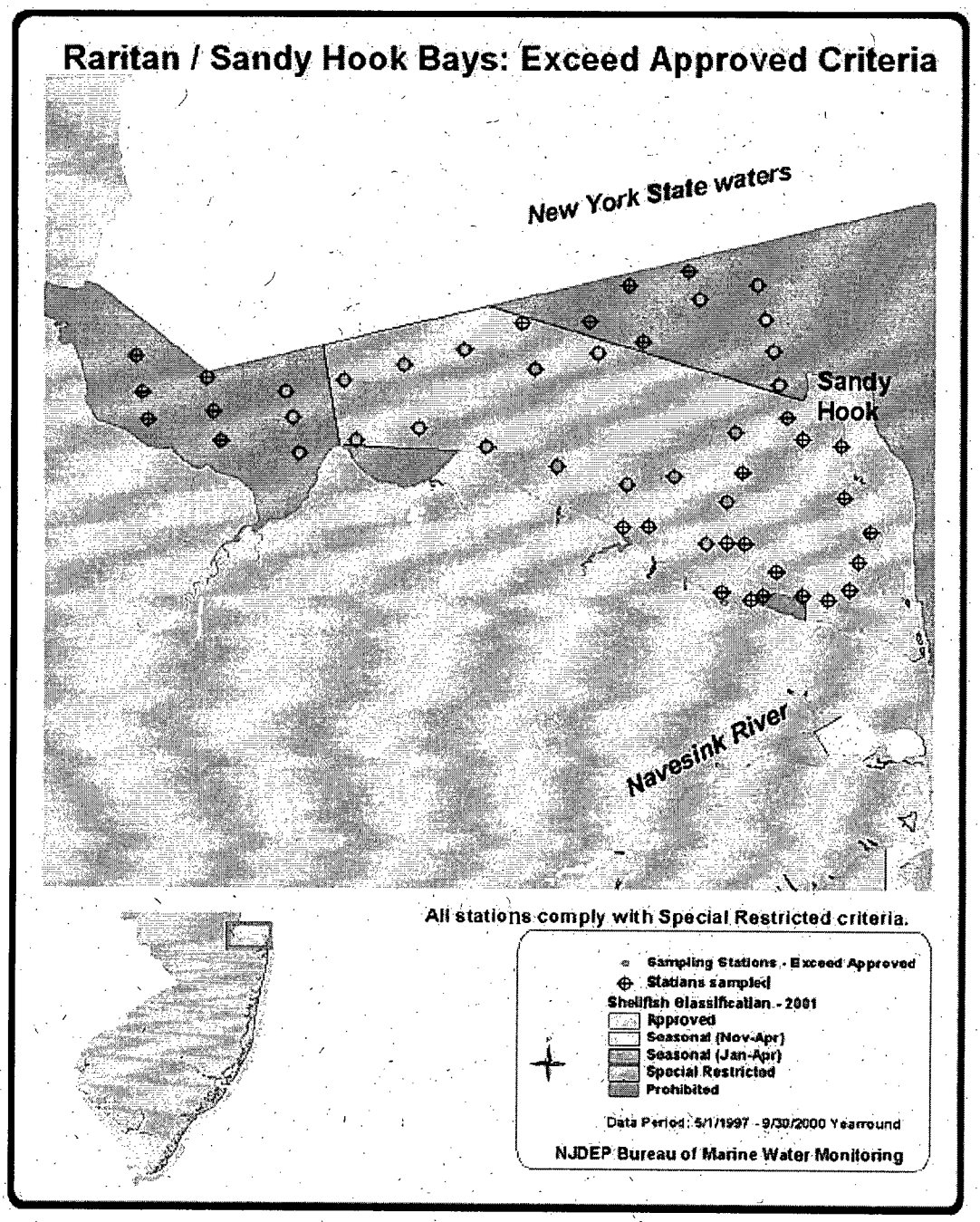



FIGURE 27: SAMPLING STATIONS EXCEEDING APPROVED CRITERIA – YEARROUND

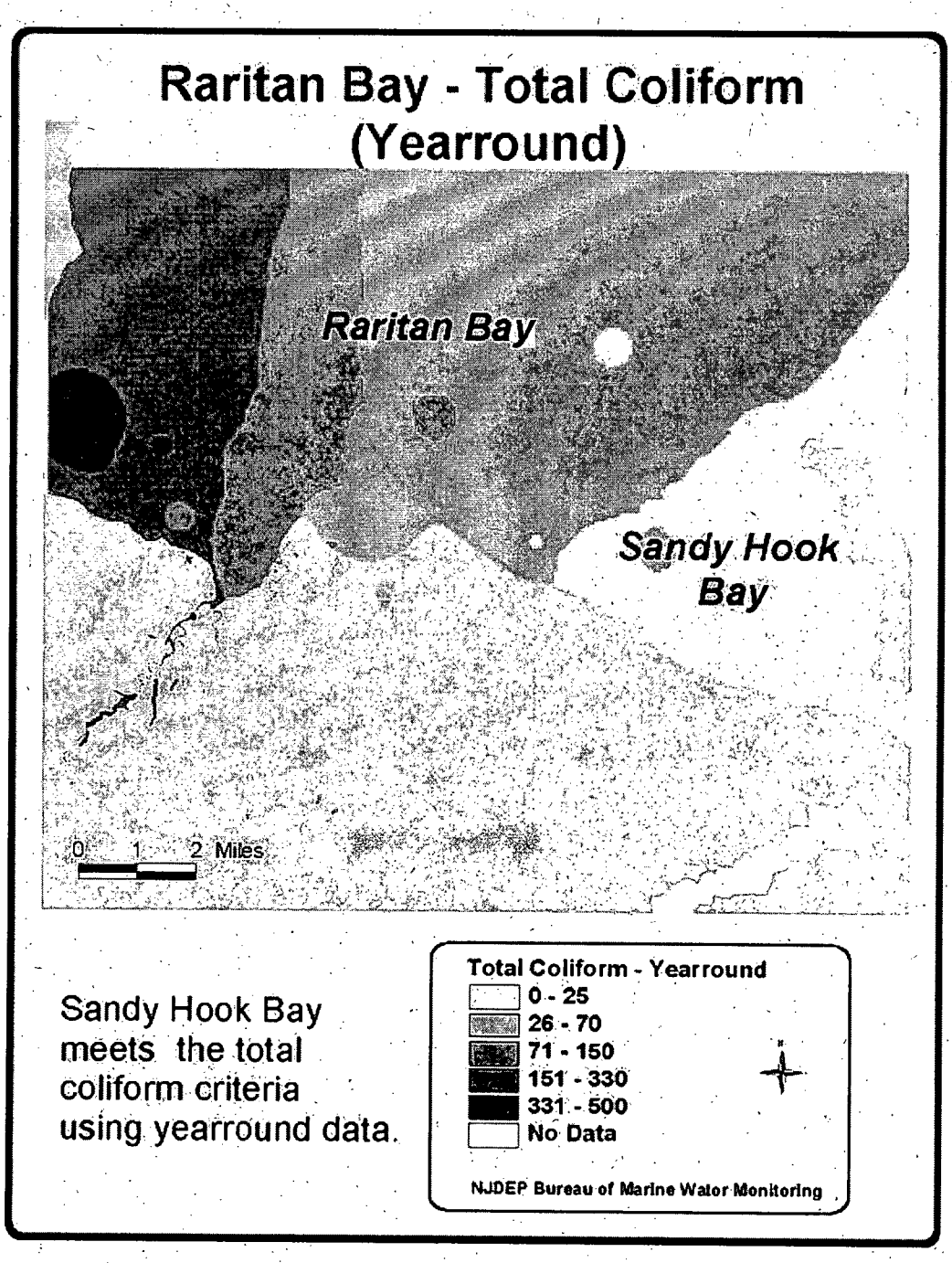



FIGURE 28: TOTAL COLIFORM LEVELS (YEARROUND)

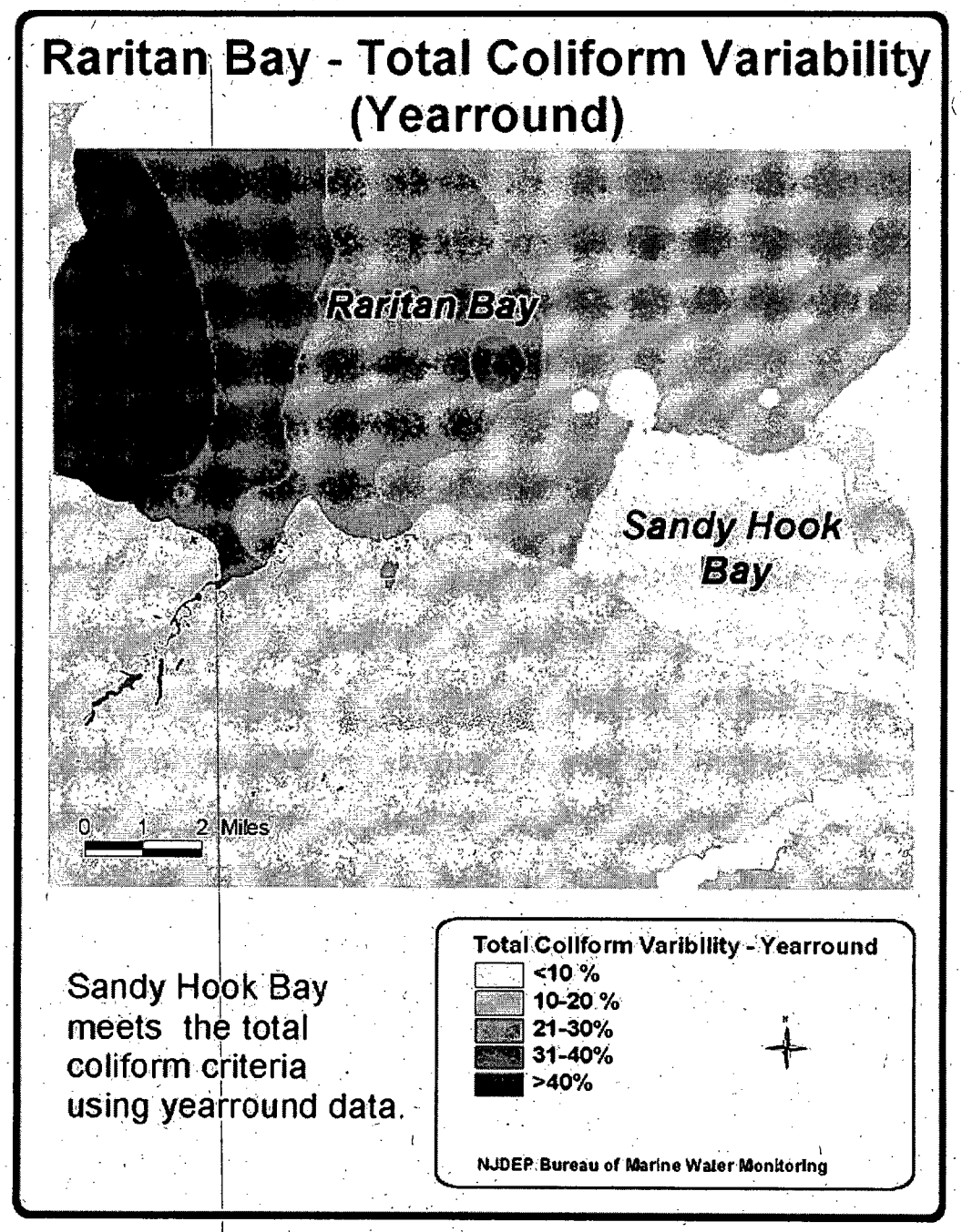



FIGURE 29: TOTAL COLIFORM VARIABILITY (YEARROUND)

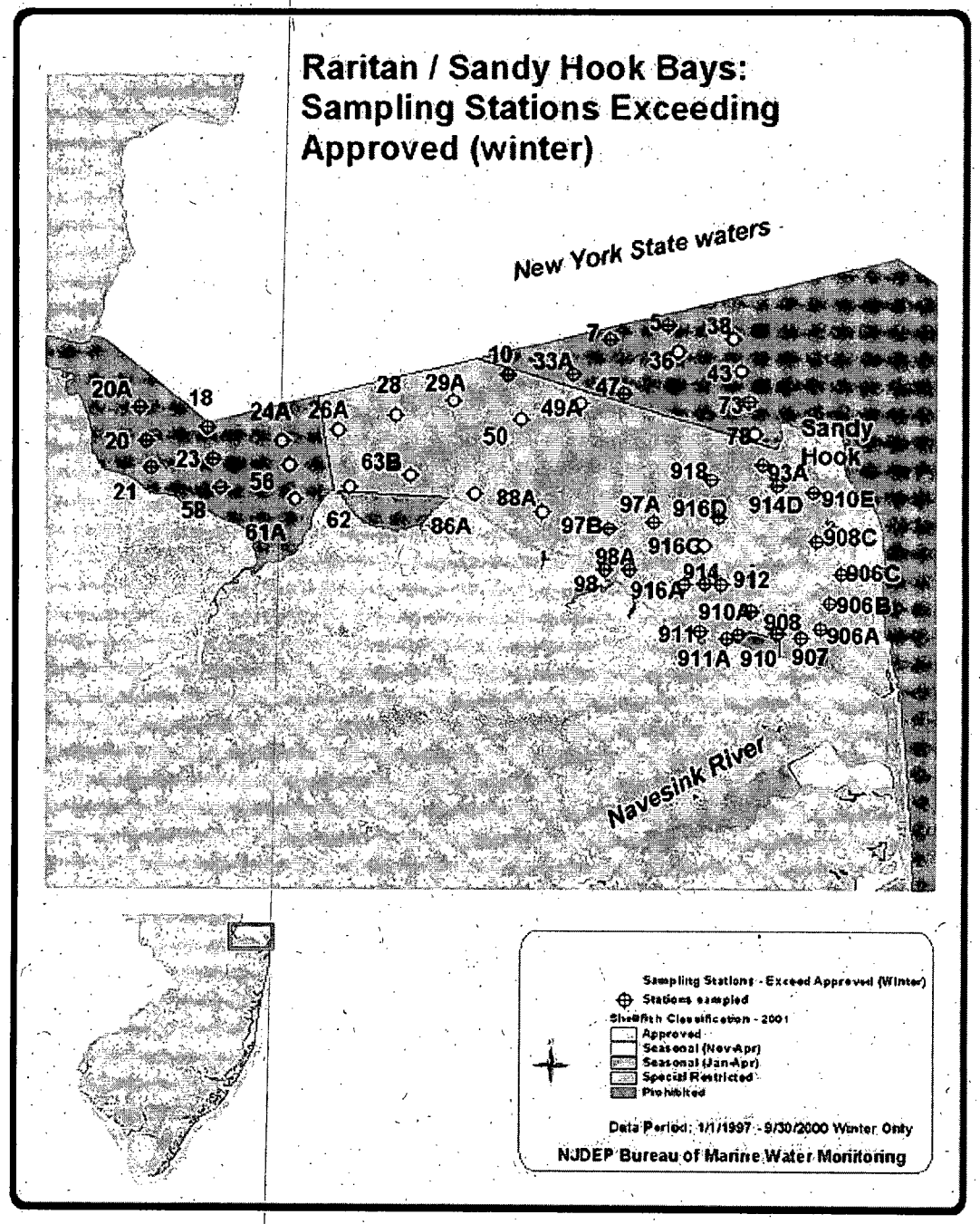



FIGURE 30: STATIONS EXCEEDING APPROVED CRITERIA DURING THE WINTER

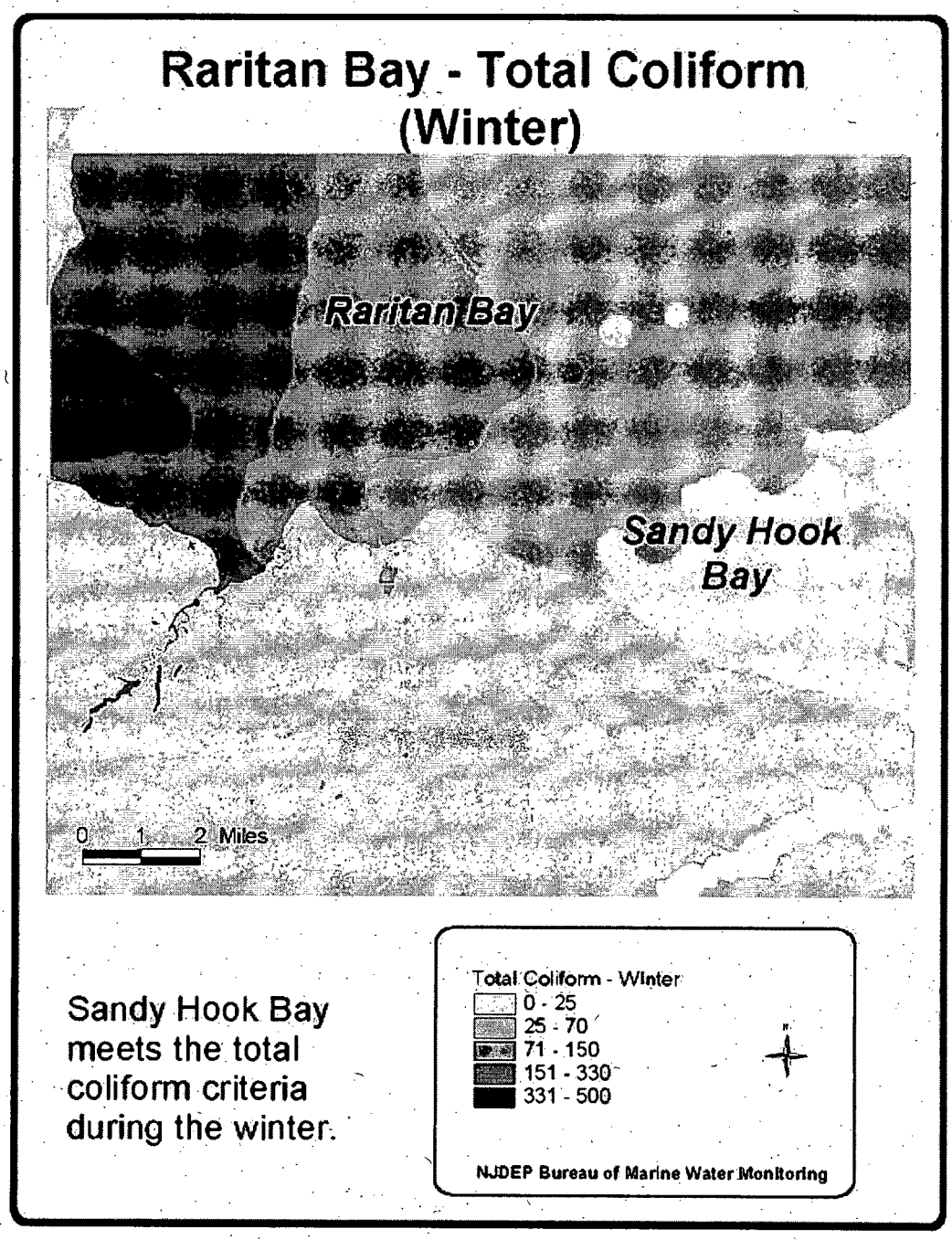



FIGURE 31: TOTAL COLIFORM LEVELS (WINTER)

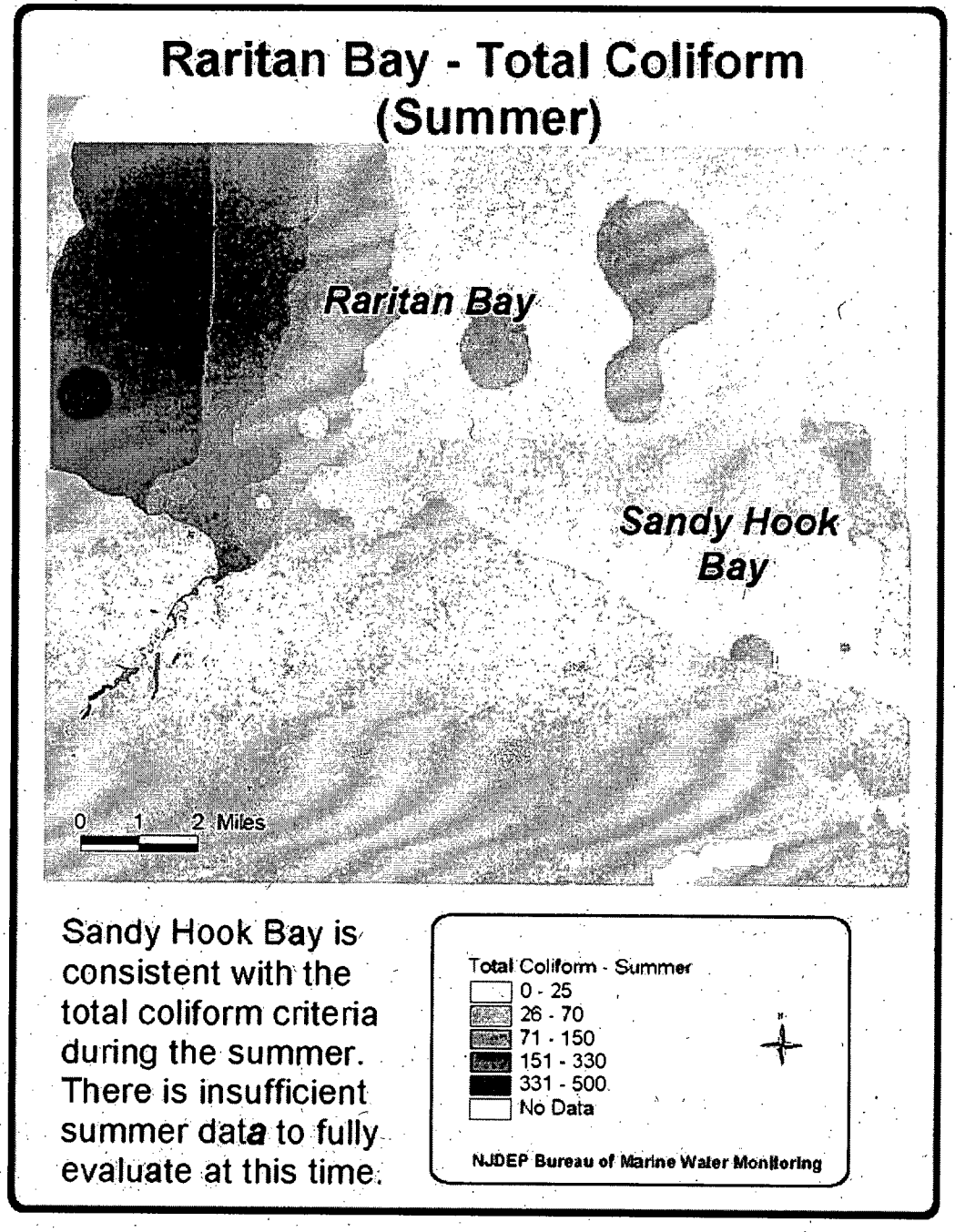



FIGURE 32: TOTAL COLIFORM LEVELS (SUMMER)

TABLE 10 : WATER QUALITY SUMMARY (5/1/1997 – 10/1/2000)

| Station | Yearround | | | Summer | | | Winter | | |
|---|---|---|---|---|---|---|---|---|---|
| | Geometric Mean | % > 330 | N | Geometric Mean | % > 330 | N | Geometric Mean | % > 330 | N |
| 10 | 67.2 | 42.9% | 7 | 37.1 | 50.0% | 2 | 85.3 | 40.0% | 5 |
| 18 | 348.9 | 57.1% | 7 | 179.6 | 50.0% | 2 | 455.0 | 60.0% | 5 |
| 20 | 354.8 | 42.9% | 7 | 319.8 | 50.0% | 2 | 369.8 | 40.0% | 5 |
| 20A | 432.7 | 57.1% | 7 | 406.2 | 50.0% | 2 | 443.7 | 60.0% | 5 |
| 21 | 280.3 | 57.1% | 7 | 310.8 | 50.0% | 2 | 269.0 | 60.0% | 5 |
| 23 | 278.6 | 42.9% | 7 | 234.9 | 0.0% | 2 | 298.2 | 60.0% | 5 |
| 24A | 133.8 | 37.5% | 16 | 40.2 | 20.0% | 5 | 231.2 | 45.5% | 11 |
| 26A | 86.2 | 31.3% | 16 | 18.4 | 0.0% | 5 | 173.6 | 45.5% | 11 |
| 28 | 71.9 | 33.3% | 15 | 22.7 | 0.0% | 4 | 109.3 | 45.5% | 11 |
| 29A | 108.6 | 31.3% | 16 | 21.3 | 0.0% | 5 | 227.7 | 45.5% | 11 |
| 33A | 29.6 | 14.3% | 7 | 14.4 | 25.0% | 4 | 77.7 | 0.0% | 3 |
| 36 | 38.6 | 20.0% | 15 | 14.5 | 14.3% | 7 | 90.9 | 25.0% | 8 |
| 38 | 25.4 | 20.0% | 15 | 11.7 | 14.3% | 7 | 50.2 | 25.0% | 8 |
| 43 | 29.4 | 20.0% | 15 | 10.1 | 14.3% | 7 | 74.7 | 25.0% | 8 |
| 47 | 57.0 | 12.5% | 8 | 37.1 | 0.0% | 3 | 73.8 | 20.0% | 5 |
| 49A | 44.6 | 12.5% | 16 | 18.6 | 0.0% | 7 | 87.8 | 22.2% | 9 |
| 5 | 31.5 | 16.7% | 6 | 54.0 | 33.3% | 3 | 18.3 | 0.0% | 3 |
| 50 | 63.4 | 25.0% | 16 | 16.6 | 0.0% | 5 | 116.7 | 36.4% | 11 |
| 56 | 206.3 | 50.0% | 16 | 117.7 | 40.0% | 5 | 266.2 | 54.5% | 11 |
| 58 | 119.1 | 28.6% | 7 | 29.4 | 0.0% | 2 | 208.5 | 40.0% | 5 |
| 61A | 90.1 | 33.3% | 15 | 19.2 | 0.0% | 5 | 195.2 | 50.0% | 10 |
| 62 | 56.3 | 31.3% | 16 | 14.8 | 0.0% | 5 | 103.2 | 45.5% | 11 |
| 63B | 47.0 | 25.0% | 16 | 9.2 | 0.0% | 5 | 98.6 | 36.4% | 11 |
| 7 | 18.9 | 14.3% | 7 | 23.1 | 25.0% | 4 | 14.4 | 0.0% | 3 |
| 73 | 25.5 | 13.3% | 15 | 14.1 | 14.3% | 7 | 42.9 | 12.5% | 8 |
| 78 | 26.9 | 26.7% | 15 | 11.7 | 14.3% | 7 | 56.0 | 37.5% | 8 |
| 86A | 44.5 | 18.8% | 16 | 21.6 | 0.0% | 5 | 61.8 | 27.3% | 11 |
| 88A | 34.7 | 20.0% | 15 | 6.6 | 0.0% | 5 | 79.2 | 30.0% | 10 |
| 906A | 11.6 | 7.1% | 14 | 26.7 | 14.3% | 7 | 5.1 | 0.0% | 7 |
| 906B | 7.3 | 0.0% | 15 | 11.2 | 0.0% | 7 | 5.0 | 0.0% | 8 |

| Station | Yearround | | | Summer | | | Winter | | |
|---|---|---|---|---|---|---|---|---|---|
| | Geometric Mean | % > 330 | N | Geometric Mean | % > 330 | N | Geometric Mean | % > 330 | N |
| 906C | 5.6 | 0.0% | 15 | 4.6 | 0.0% | 7 | 6.7 | 0.0% | 8 |
| 907 | 10.5 | 0.0% | 14 | 19.5 | 0.0% | 7 | 5.7 | 0.0% | 7 |
| 908 | 12.4 | 0.0% | 13 | 15.1 | 0.0% | 6 | 10.4 | 0.0% | 7 |
| 908C | 8.0 | 0.0% | 15 | 5.8 | 0.0% | 7 | 10.5 | 0.0% | 8 |
| 910 | 15.5 | 0.0% | 5 | 43.0 | 0.0% | 1 | 12.1 | 0.0% | 4 |
| 910A | 18.2 | 0.0% | 8 | 19.5 | 0.0% | 5 | 16.1 | 0.0% | 3 |
| 910E | 11.0 | 6.7% | 15 | 4.9 | 0.0% | 7 | 22.1 | 12.5% | 8 |
| 911 | 9.0 | 0.0% | 7 | 6.4 | 0.0% | 4 | 14.2 | 0.0% | 3 |
| 911A | 11.2 | 0.0% | 7 | 8.0 | 0.0% | 4 | 17.4 | 0.0% | 3 |
| 912 | 12.3 | 0.0% | 13 | 8.7 | 0.0% | 6 | 16.4 | 0.0% | 7 |
| 914 | 12.9 | 7.7% | 13 | 8.0 | 0.0% | 6 | 19.5 | 14.3% | 7 |
| 914D | 14.7 | 0.0% | 14 | 8.7 | 0.0% | 7 | 24.8 | 0.0% | 7 |
| 916A | 27.6 | 12.5% | 16 | 11.2 | 14.3% | 7 | 55.7 | 11.1% | 9 |
| 916C | 14.2 | 13.3% | 15 | 6.4 | 0.0% | 6 | 24.2 | 22.2% | 9 |
| 916D | 20.6 | 6.3% | 16 | 14.3 | 14.3% | 7 | 27.4 | 0.0% | 9 |
| 918 | 22.0 | 13.3% | 15 | 12.5 | 14.3% | 7 | 36.2 | 12.5% | 8 |
| 93A | 21.1 | 6.7% | 15 | 7.8 | 0.0% | 7 | 50.4 | 12.5% | 8 |
| 97A | 43.2 | 12.5% | 16 | 26.7 | 14.3% | 7 | 62.8 | 11.1% | 9 |
| 97B | 24.4 | 12.5% | 16 | 13.6 | 14.3% | 7 | 38.5 | 11.1% | 9 |
| 98 | 25.2 | 14.3% | 7 | 20.2 | 0.0% | 4 | 33.8 | 33.3% | 3 |
| 98A | 18.2 | 14.3% | 7 | 24.9 | 25.0% | 4 | 11.9 | 0.0% | 3 |
| Total Samples | | | 632 | | | 261 | | | 371 |

## *TIDAL AND SEASONAL EFFECTS*

There are no stations that show a significant tidal or seasonal effect.

In many cases, coliform levels for samples collected on the ebb tide are greater than levels for samples collected on the flood tide. It should be noted that samples are collected on the ebb tide to the extent possible.

Differences between summer and winter values were not statistically significant, due in part to the variability of coliform levels.

## *RAINFALL EFFECTS*

Non-point source pressures on shellfish beds in New Jersey originate in materials that enter the water via stormwater. These materials include bacteria, as well as other waste that enters the stormwater collection system.

Historical data comparing the difference between fecal coliform levels measured after rainfall with those during dry periods were compared to generate the map below. The Bureau of Marine Water Monitoring has begun to identify particular storm water outfalls that discharge excessive bacteriological loads during storm events. In some cases, specific discharge points can be identified. When specific outfalls are identified as significant sources, the Department works with the county and municipality to further define the source(s) of the contamination and implement remediation activities.

It should be noted that a particular short-term data set may not indicate significant rainfall effects even if the historical data indicate that a significant effect occurs in a particular area. This is due to one or more of the following factors:

Data during the short term may consist of primarily rainfall data or dry weather data. In this case, if there are insufficient data points in each category, the test for significance cannot be done.

Data collected after rainfall in the normal sampling regime may miss the effects of the 'first flush'.

Rainfall data is based on the closest established NOAA station. Since rainfall patterns along the coastline, particularly during the summer months, tend to include locally heavy rainfall, the rainfall amounts recorded at the NOAA station may not accurately reflect the rainfall at the sampling station(s).

Based on this data set, there are several stations that show a statistically significant correlation of coliform level with rainfall. Since samples are collected in this area only after rainfall, it is unlikely that a statistical relationship would be shown from this data set. However, there are several stations that tend to show a rainfall impact, with increasing levels of coliform bacteria after rainfall, as shown below.

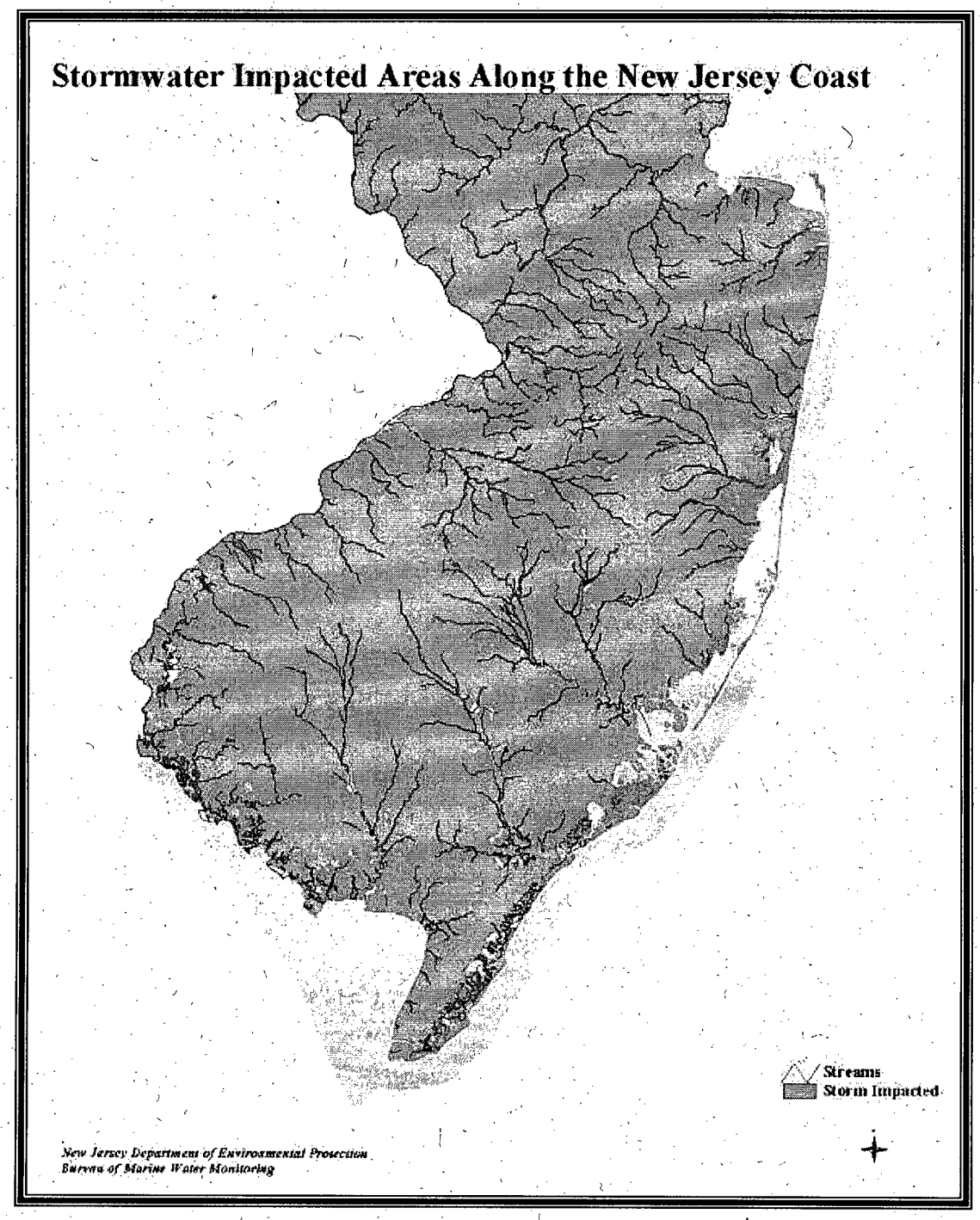



FIGURE 33 : AREAS IMPACTED BY RAINFALL (STATEWIDE)

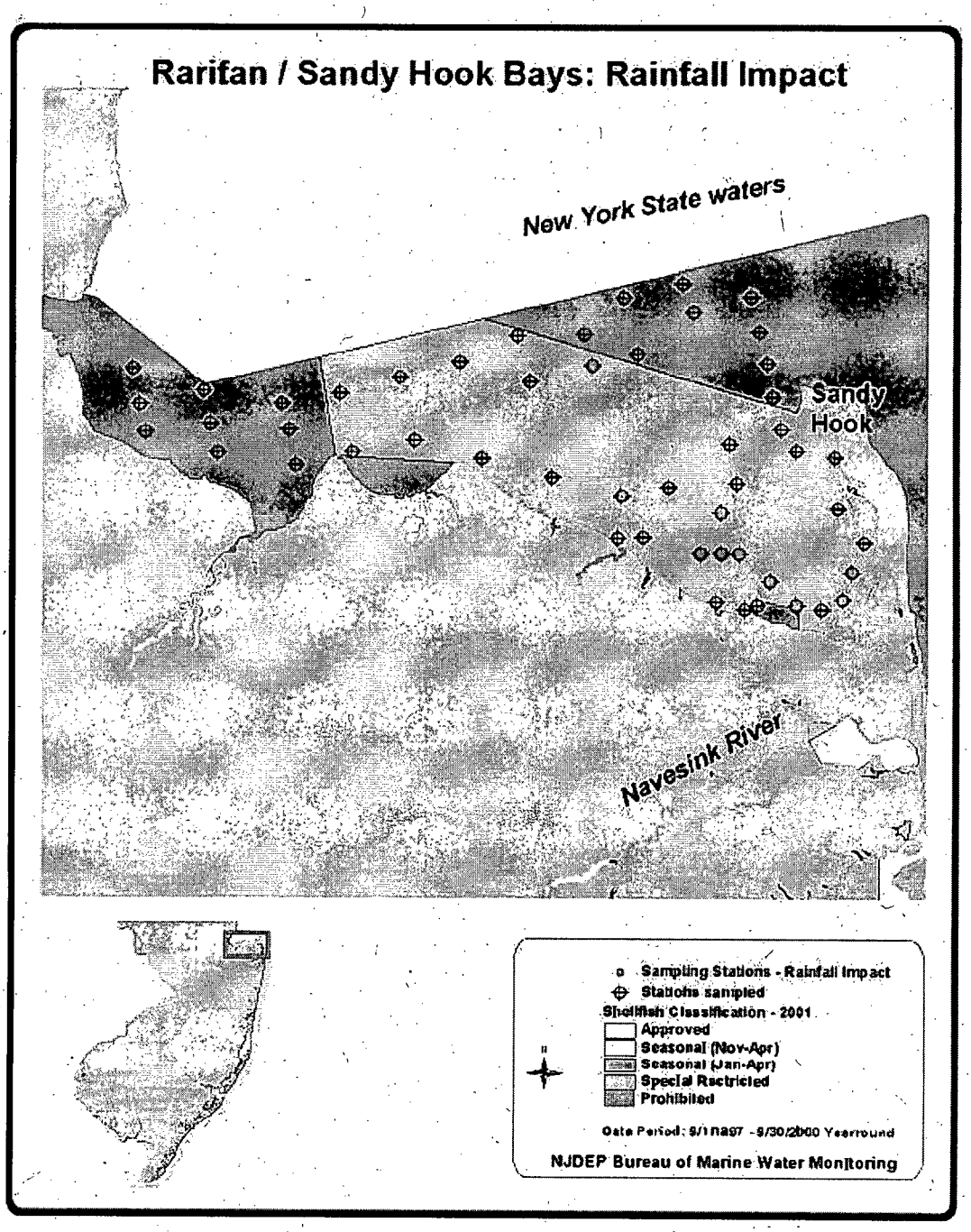



FIGURE 34: STATIONS TENDING TO SHOW A RAINFALL IMPACT

## RELATED STUDIES

In 1986, the National Oceanic and Atmospheric Administration (NOAA) National Status and Trends Program initiated the Mussel Watch Project. NOAA has annually collected and analyzed mussels and oysters from 276 sites around the coastal and estuarine waters of the United States. Of these, 125 sites (46%) are within 20 km of urban areas. It should be noted that both the blue mussel and the oyster accumulate most toxicants at a higher rate than either hard or soft clams, so that tissue concentrations in those species would ordinarily be higher than concentrations in clam tissue sampled in the same area.

One of these sites is located in this area approximately two miles northwest of Sandy Hook in Prohibited waters. Another site is located approximately three miles north of Conaskonk Point in New York State waters.

At the site located northwest of Sandy Hook, the blue mussel, Mytilus edulis, was identified as having 'relatively high' concentrations of copper, mercury, nickel, lead, chlordane, dieldrin, DDT, PCB's, and PAH's (NOAA, 1998). The 'relatively high' concentration was defined as the high end of the overall distribution of concentrations in mollusks at the 36 most urban sites (over 800,000 people) being monitored. The chemical analysis was based on dry weight concentrations.

The 'relatively high' designation by the Mussel Watch Project does not necessarily mean that FDA Standards have been exceeded based on wet weight concentrations. An evaluation of the data by the Bureau of Marine Water Monitoring found that only the levels of lead in the blue mussel at the site near Sandy Hook exceeded the FDA's recommended criteria based on wet sample analysis. It should be noted that the blue mussel tends to accumulate toxicants such as metals at higher rates than clams.

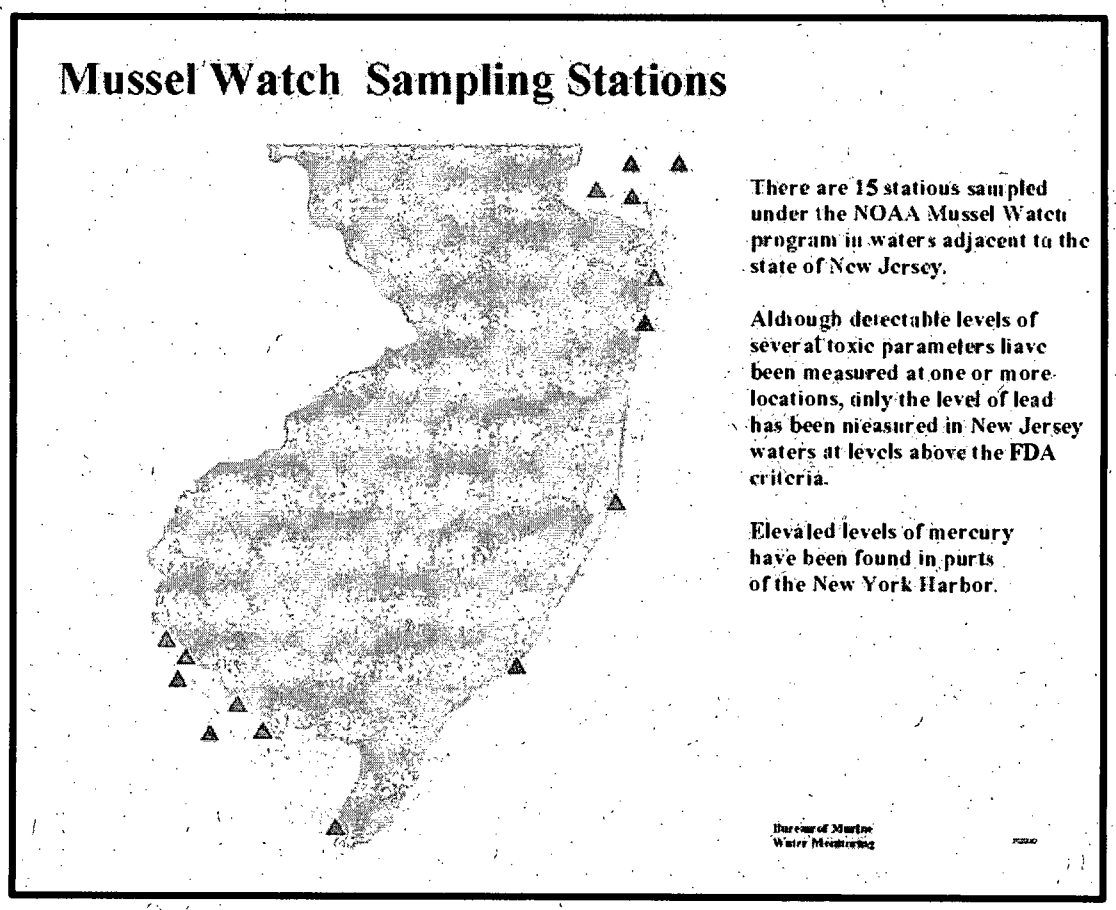



FIGURE 35: SAMPLING SITES WHERE NOAA MUSSEL WATCH DATA HAS BEEN COLLECTED

## *TOXICS MONITORING PROGRAM*

### Previous Toxics Monitoring by NJDEP

In 1984, the New Jersey Department of Environmental Protection, Bureau of Marine Water Monitoring, identified elevated levels of lead and chromium in the soft clam, Mya arenaria, in the vicinity of the Atlantic Highlands Municipal Marina (Feerst, 1984). This area has been excluded as a shellfish harvesting area. Data collected by the DEP in 1999-2000 indicate that these levels are not currently high enough to cause human toxicity. (See the discussion below.)

Monitoring of toxic pollutants in shellfish tissue was also performed in the nearby waters of the Navesink River and the Shrewsbury River. These measurements were made at four selected sites in October 1995, May 1996, and August 1996. This work was sponsored by the New Jersey Department of Environmental Protection and was performed by Rutgers University as part of a study of the

impacts of docks and piers on heavy metals concentrations in shellfish tissue.

Tissue Data Collected by NJDEP in 1999-2000

Between October 1999 and August 2000, The NJDEP collected a series of hard clam tissue samples that were analyzed for a suite of parameters. These included PCBs, PAH, and seven heavy metals (mercury, lead, copper, chromium, arsenic, nickel, and cadmium). Funding for analysis was provided by the USEPA. Samples were analyzed by Battelle Laboratories.

It should be noted that the variability inherent in tissue analyses is higher than would be anticipated in a water matrix.

All results are significantly lower than the applicable FDA criteria (in the case of mercury) or level of concern (for other parameters). Most results are at least a factor of 10 and in many cases a factor of 100 less than the applicable standard.

Most results are likewise below the more stringent USEPA Screening Values updated in 2000 (based on updated IRIS values and consumption studies). These values are used as an indication of areas where more data are needed to make a determination regarding human and/or ecosystem health issues. Many of the arsenic values are close to or greater than the USEPA Screening Value for arsenic (maximum value measured was 1.8 ?g As/g; screening value is 1.2 ?g As/g) Likewise, several values are close to or above the screening value for total PCBs (maximum value measured was 41 ?g/kg; screening value is 20 ?g/kg) When these screening values are exceeded, it is recommended that further analyses should be conducted. In addition, the samples were analyzed for total arsenic, rather than inorganic arsenic. The organic form of arsenic is not readily available within the tissue and is therefore of limited risk.

Chromium levels were elevated in the vicinity of the Atlantic Highlands Marina. This area was previously identified as having elevated levels of chromium and the area was placed in a Prohibited status for harvesting shellfish. While the levels are no longer above the FDA Level of Concern, they are still elevated.

There is only one PAH, benzo(a)pyrene, for which the USEPA has developed a screening value. This compound has high carcinogenic capacity. While all values were well below the screening value, it should be noted that the compound was detected in measurable quantities in all samples. Toxic Equivalents (TEQs) were determined for PAH's based on benzo(a)pyrene (G. Buchanan and G. Post – personal communication). The average TEQ for PAHs in these shellfish samples is 1.05 ?g/kg which is well below the EPA screening value of 5.47 ?g/kg.

Contaminants, such as PCBs, accumulate in fatty tissue and increase in concentration as you move up the food chain. Shellfish are typically lower in lipids as compared to fish, and are low on the food chain. For these reasons, PCB levels in shellfish will be substantially lower compared to fish species in the same waters. Levels of PCBs in shellfish were much lower as compared to PCB levels in fish tissue from this region. Levels of mercury in shellfish were also substantially lower when compared to levels in fish species.

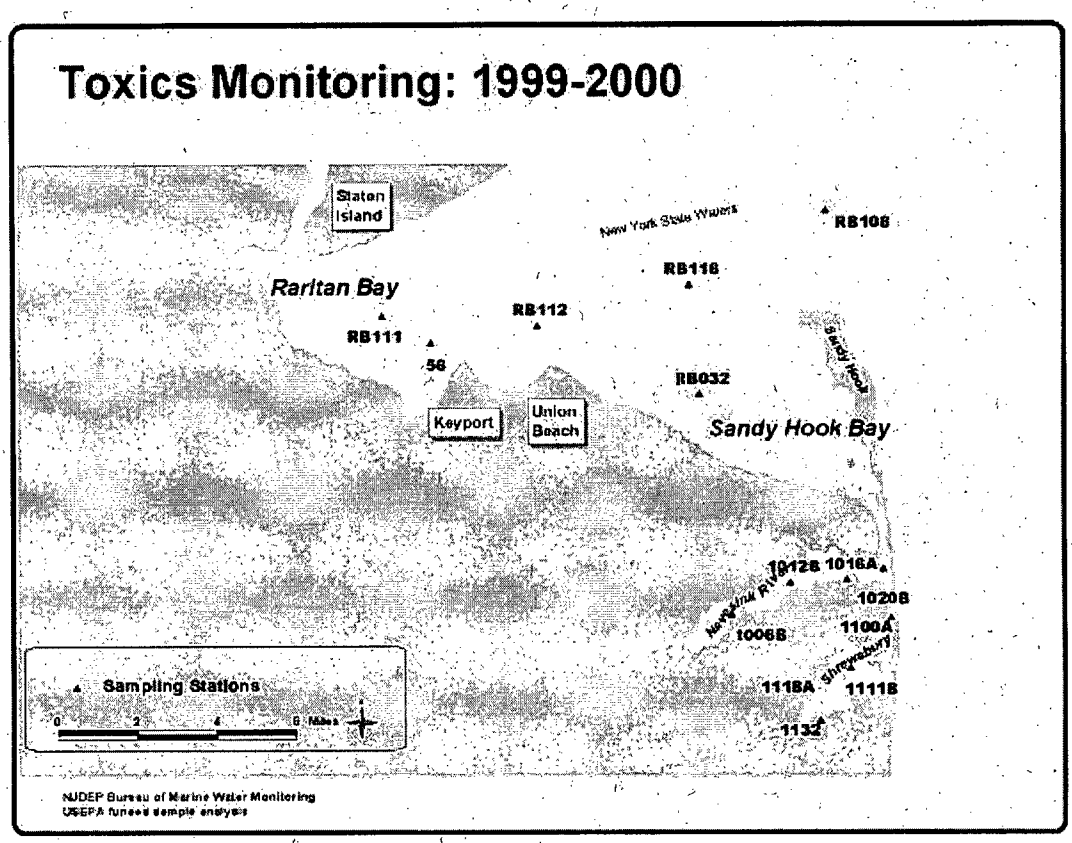
| Station | N | Cr | Ni | Cu | As | Cd | Pb | Hg |
|---|---|---|---|---|---|---|---|---|
| Stations in Raritan / Sandy Hook Bays | | | | | | | | |
| RB032 | 3 | 0.498 | 1.137 | 1.931 | 1.668 | 0.164 | 0.400 | 0.037 |
| RB56 | 4 | 0.345 | 0.933 | 2.191 | 1.224 | 0.178 | 0.355 | 0.021 |
| RB108 | 4 | 1.224 | 1.869 | 1.002 | 1.377 | 0.075 | 0.297 | 0.018 |
| RBI11 | 4 | 0.338 | 0.897 | 2.280 | 1.357 | 0.210 | 0.371 | 0.023 |
| RB112 | 5 | 0.414 | 0.957 | 2.000 | 1.538 | 0.161 | 0.298 | 0.024 |
| RB116 | 4 | 0.421 | 1.102 | 1.873 | 1.497 | 0.149 | 0.357 | 0.037 |
| USEPA tissue screening level (USEPA, 2000) | | Not available | Not available | Not available | 1.2 | 4 | Not available | 0.4 |
| USFDA tissue standard (ISSC, 2003) | | 13 | 80 | Not available | 86 | 4 | 1.7 | 1.0 |

TABLE 11: RESULTS OF METALS TISSUE ANALYSES (MEAN VALUE, RESULTS IN ?G/G WET WEIGHT)

| Station | N | Total PCB | Total PAH | Benzo(a)pyrene |
|---|---|---|---|---|
| Statibns in Raritan / Sandy Hook Bays | | | | |
| RB032 | 3 | 19.58 | 39.20 | 0.82 |
| RB56 | 4 | 22.56 | 31.51 | 0.70 |
| RB108 | 4 | 18.35 | 27.09 | 0.83 |
| RB111 | 4 | 25.67 | 29.56 | 0.61 |
| RB112 | 5 | 19.63 | 29.96 | 0.62 |
| RB116 | 4 | 16.84 | 30.60 | 0.75 |
| USEPA tissue screening level (USEPA 2000) | | 20 | Not available | 5.46 |
| USFDA tissue standard | | 2000 | Not available | Not available |

TABLE 12: RESULTS OF PCB AND PAH TISSUE ANALYSIS (MEAN VALUE, RESULTS IN ?G/KG WET WEIGHT)

FIGURE 36: SAMPLING STATIONS



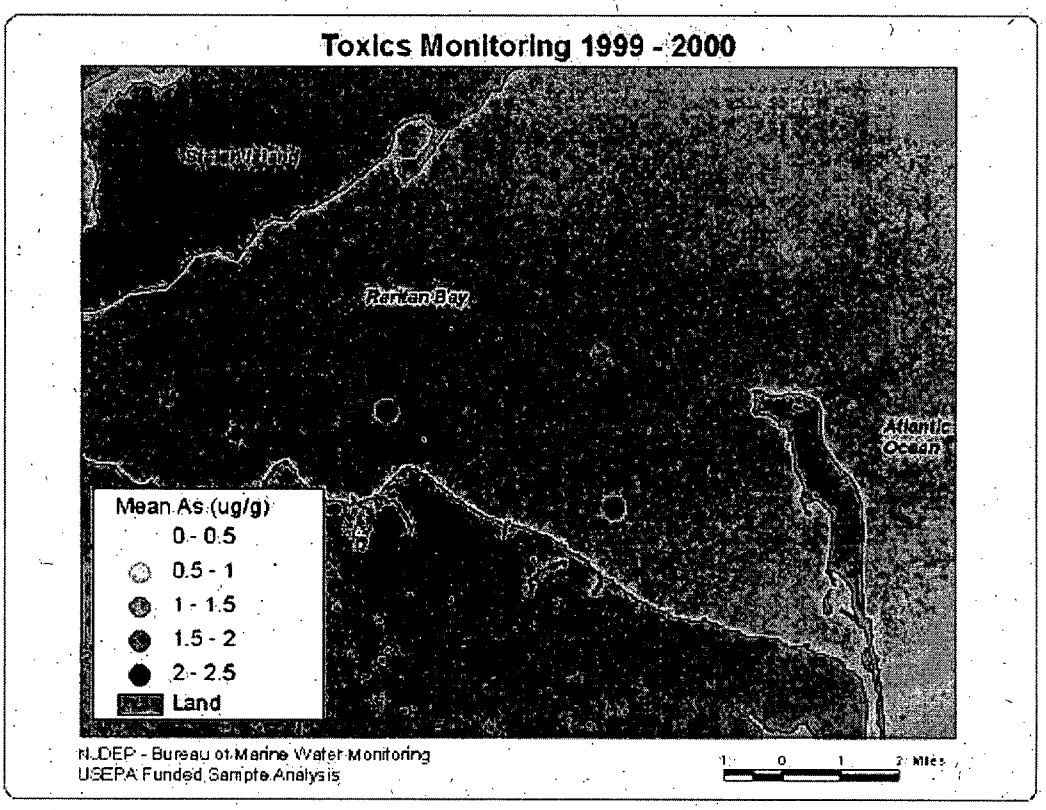



FIGURE 37 : ARSENIC MEAN VALUES (RESULTS AS ? G/G WET WEIGHT)

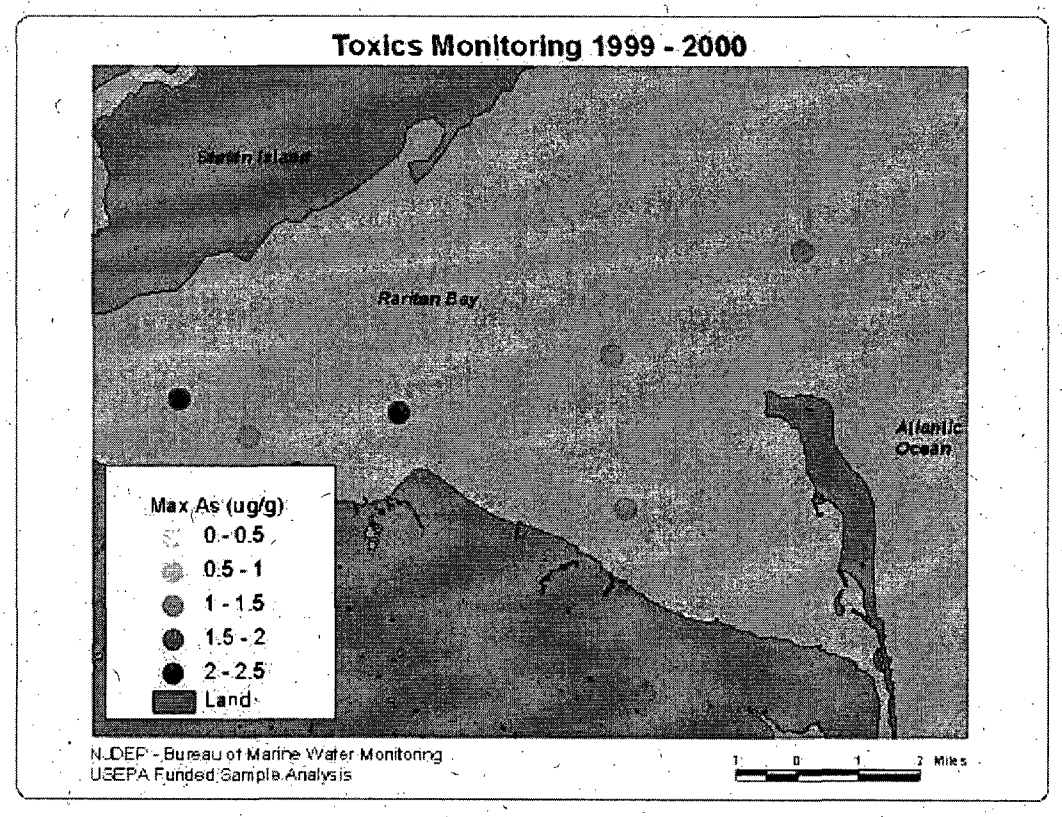



FIGURE 38: ARSENIC MAXIMUM VALUES (RESULTS IN ? G/G WET WEIGHT)

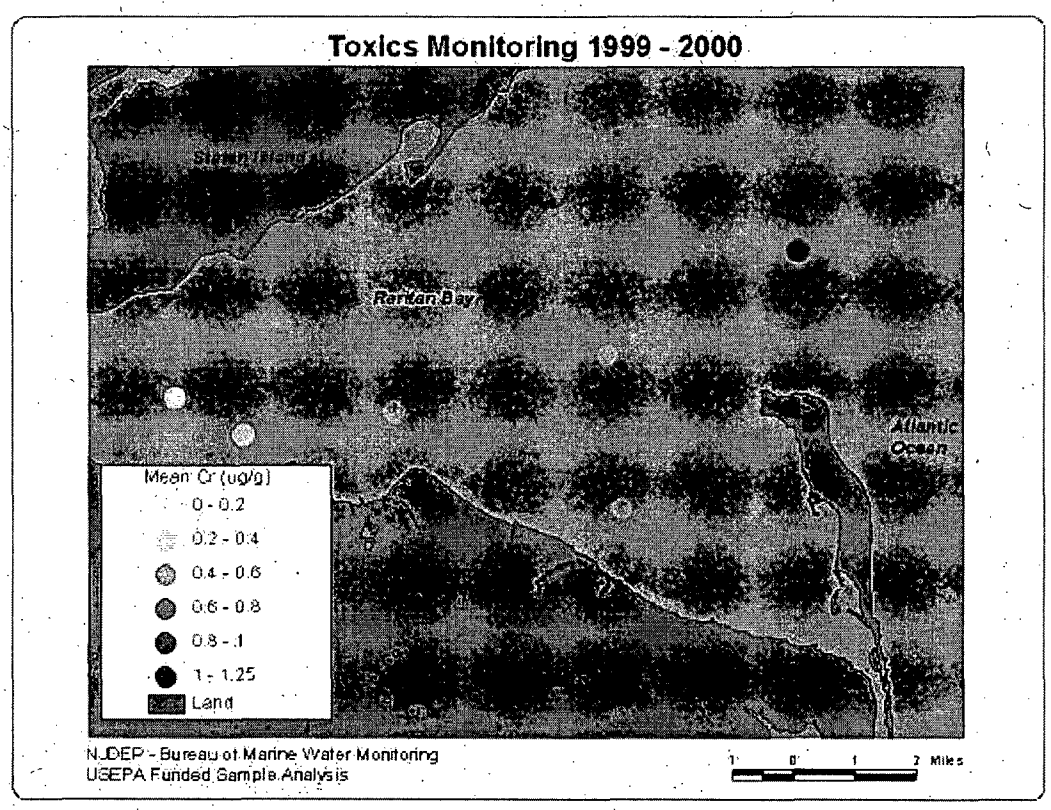



FIGURE 39: CHROMIUM MEAN VALUES (RESULTS IN ? G/G WET WEIGHT)

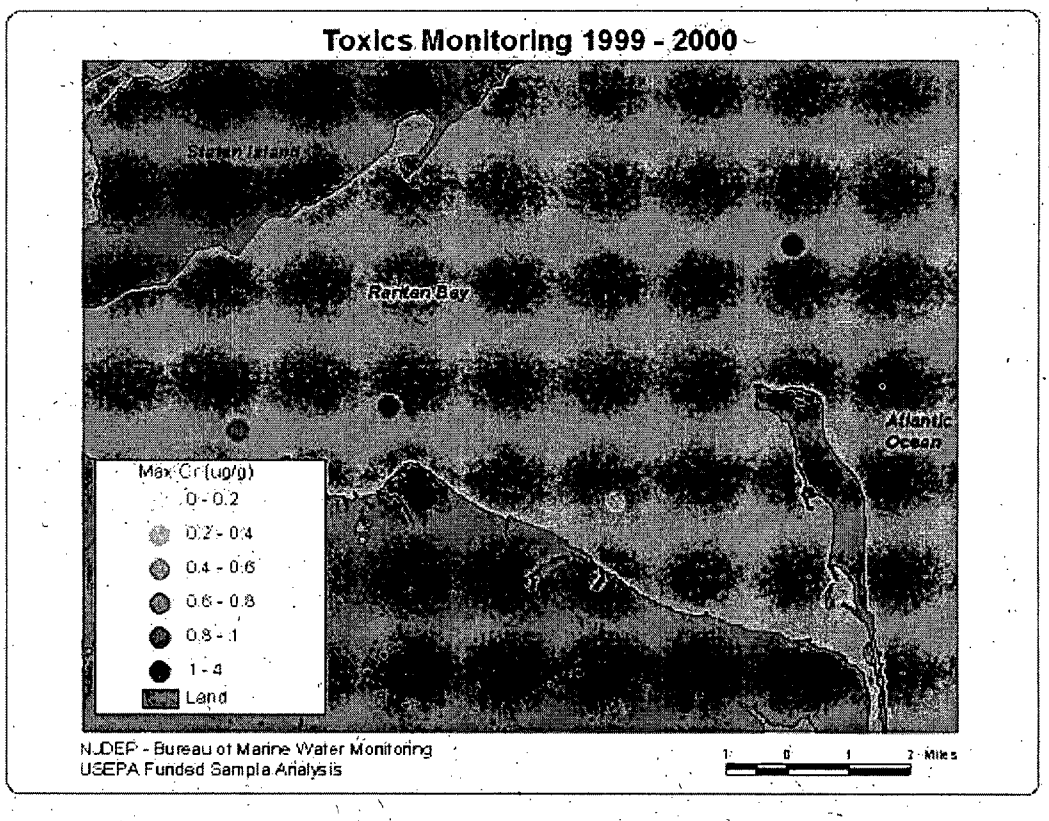



FIGURE 40: CHROMIUM MAXIMUM VALUES (RESULTS IN ? G/G WET WEIGHT)

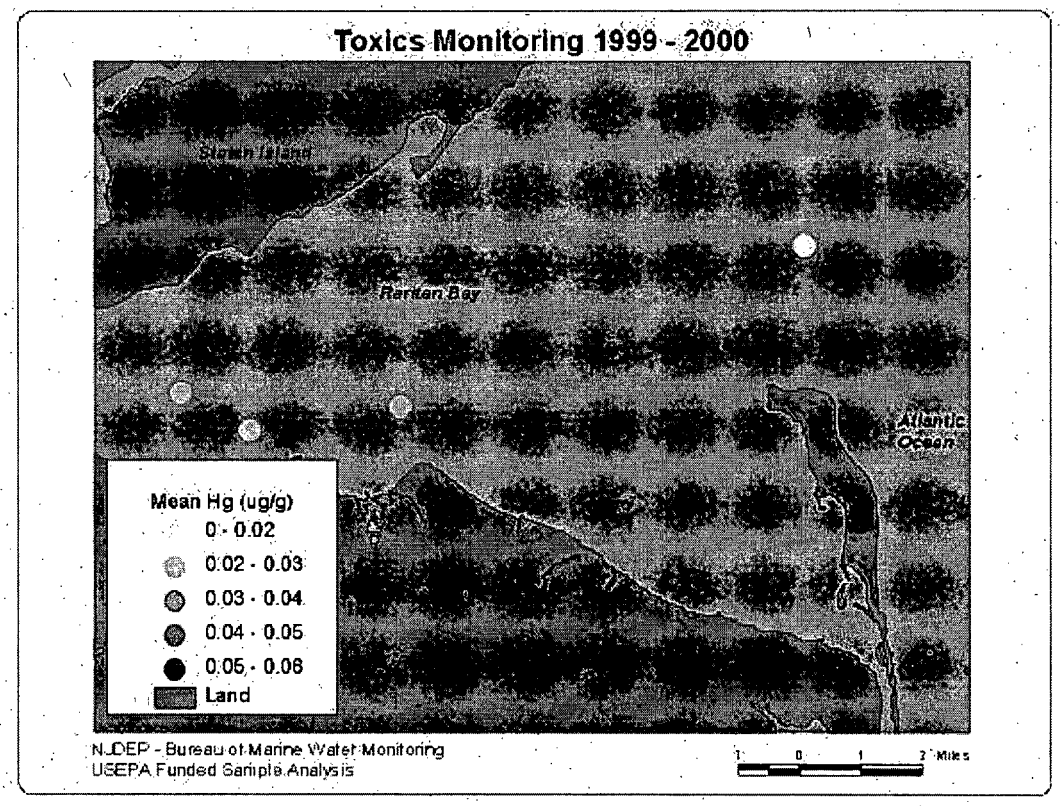



FIGURE 41: MERCURY MEAN VALUES (RESULTS IN ? G/G WET WEIGHT)

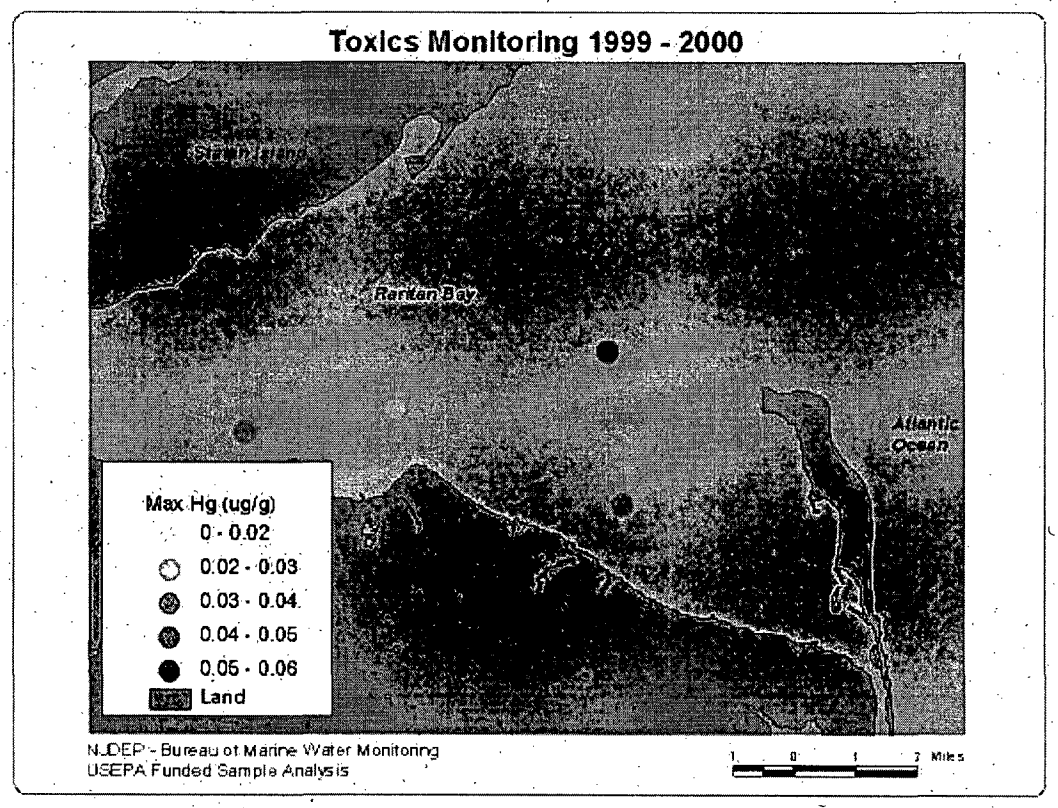



FIGURE 42: MERCURY MAXIMUM VALUES (RESULTS IN ? G/G WET WEIGHT)

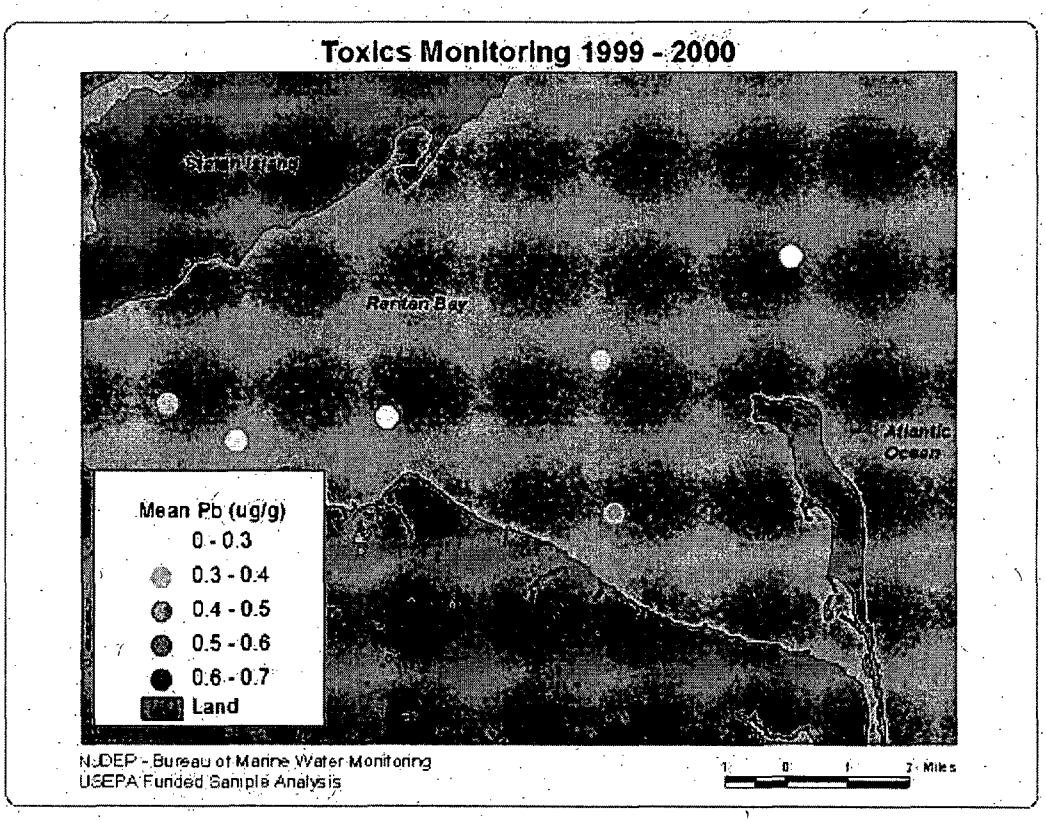



FIGURE 43: LEAD MEAN VALUES (RESULTS IN ? G/G WET WEIGHT)

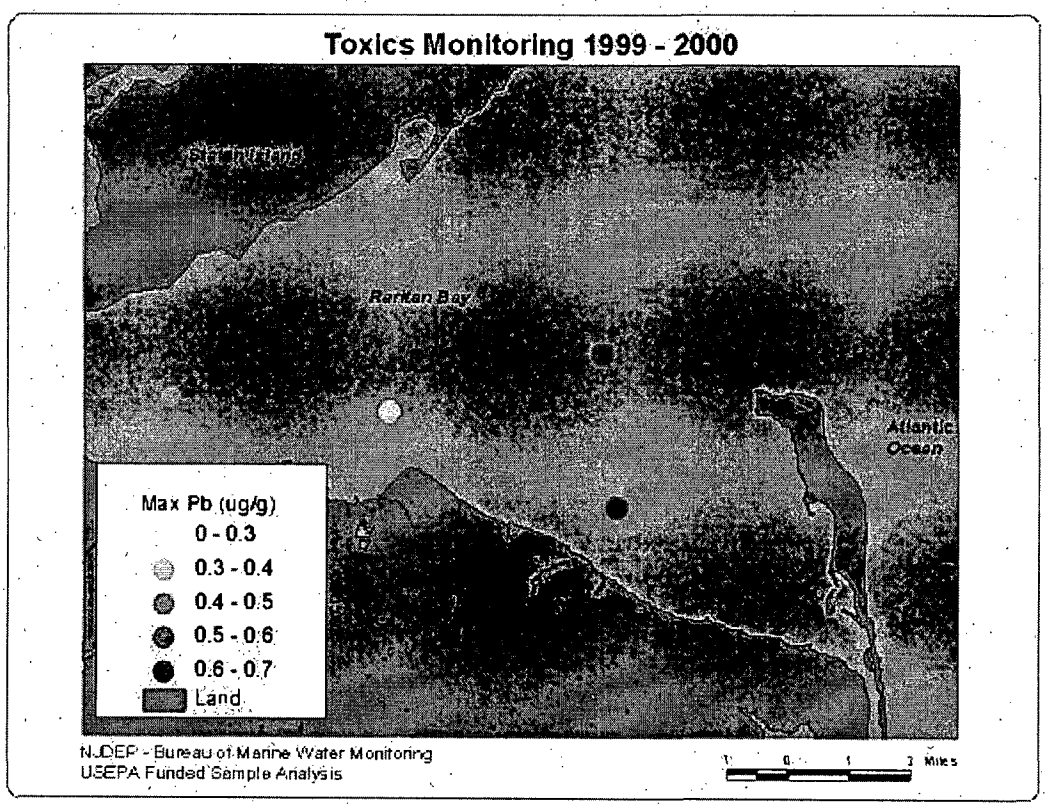



FIGURE 44: LEAD MAXIMUM VALUES (RESULTS IN ? G/G WET WEIGHT)

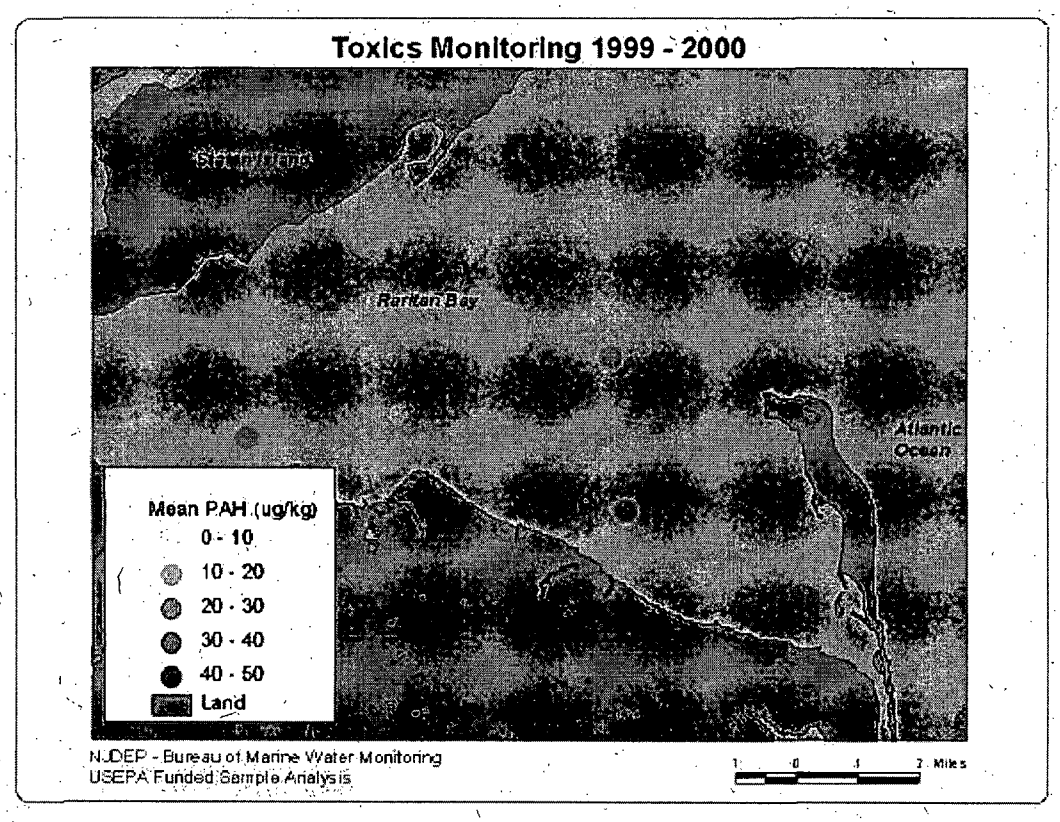



FIGURE 45: TOTAL PAH MEAN VALUES (RESULTS IN ? G/KG WET WEIGHT)

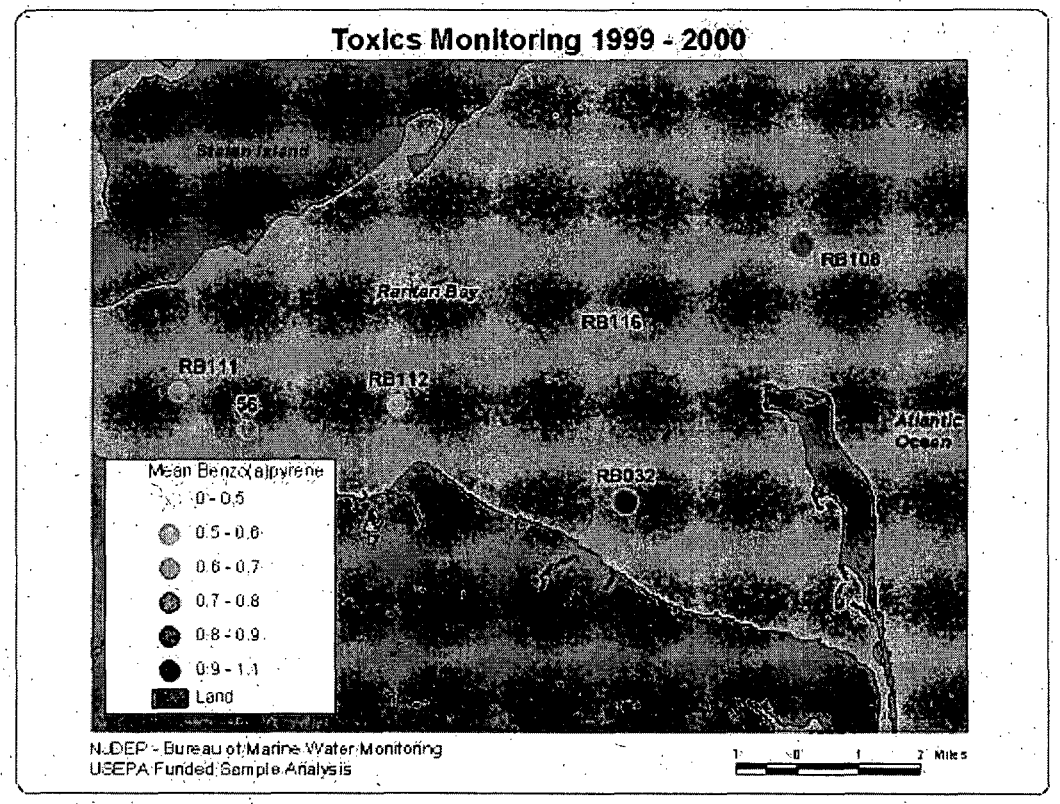



FIGURE 46: MEAN BENZO(A)PYRENE VALUES (RESULTS IN ? G/KG WET WEIGHT)

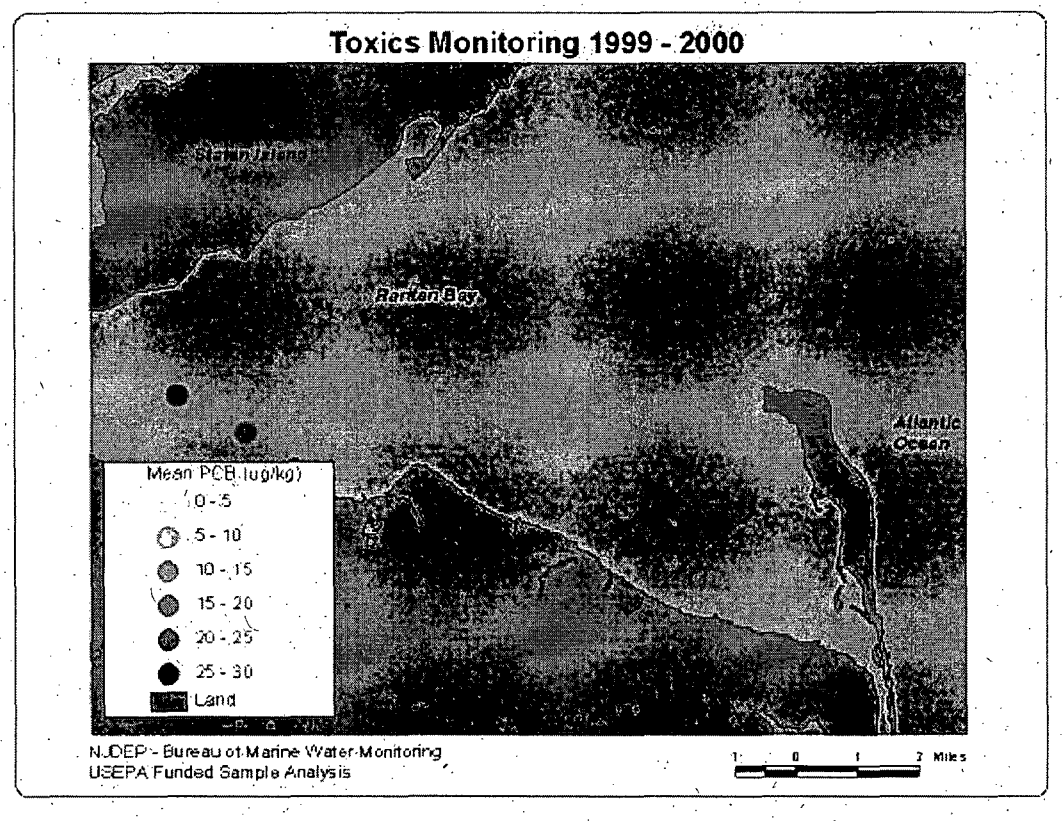



FIGURE 47: TOTAL PCB MEAN VALUES (RESULTS IN ? G/KG WET WEIGHT)

These data indicate that:

- ? All sampling stations comply with the current FDA criteria.
- ? Most stations exceed the USEPA screening value for arsenic.

Further study should attempt to identify the likely sources.

## *BATHING BEACH DATA*

### 1997

On June 4, 1997, two beached were closed in Leonardo and Keansburg due to high bacteria levels. On August 7, 1997, beaches in Middletown were closed as a precautionary measure during an algal bloom.

### 1998

On July 22-23, 1998, beaches in Leonardo and Middletown were closed as a precautionary measure after an unpermitted discharge of 7.9 MG from MCBOA.

1999

On July 8-12, 1999, beaches in Leonardo were closed due to high bacterial levels.

2000

On July 5-6 and July 12-13, 2000, beaches in Highlands were closed due to high bacterial levels. (Loftin, 2001).

## *ESTUARINE MONITORING PROGRAM*

The Department routinely collects four samples per year at a subset of the NSSP sampling locations to be evaluated for a suite of organic and inorganic parameters related to primary productivity and nutrient dynamics. Of the 250 stations routinely sampled for this expanded suite of parameters, 15 are located in Raritan Bay or Sandy Hook Bay.

Concentrations of phosphorus and nitrogen tend to be higher in this area than in most other parts of the State, suggesting higher levels of primary productivity. Higher levels of nutrients also correlate with elevated levels of chlorophyll-a in the samples. In addition, there are frequent sampling dates, especially during warm weather, when dissolved oxygen levels are depressed.

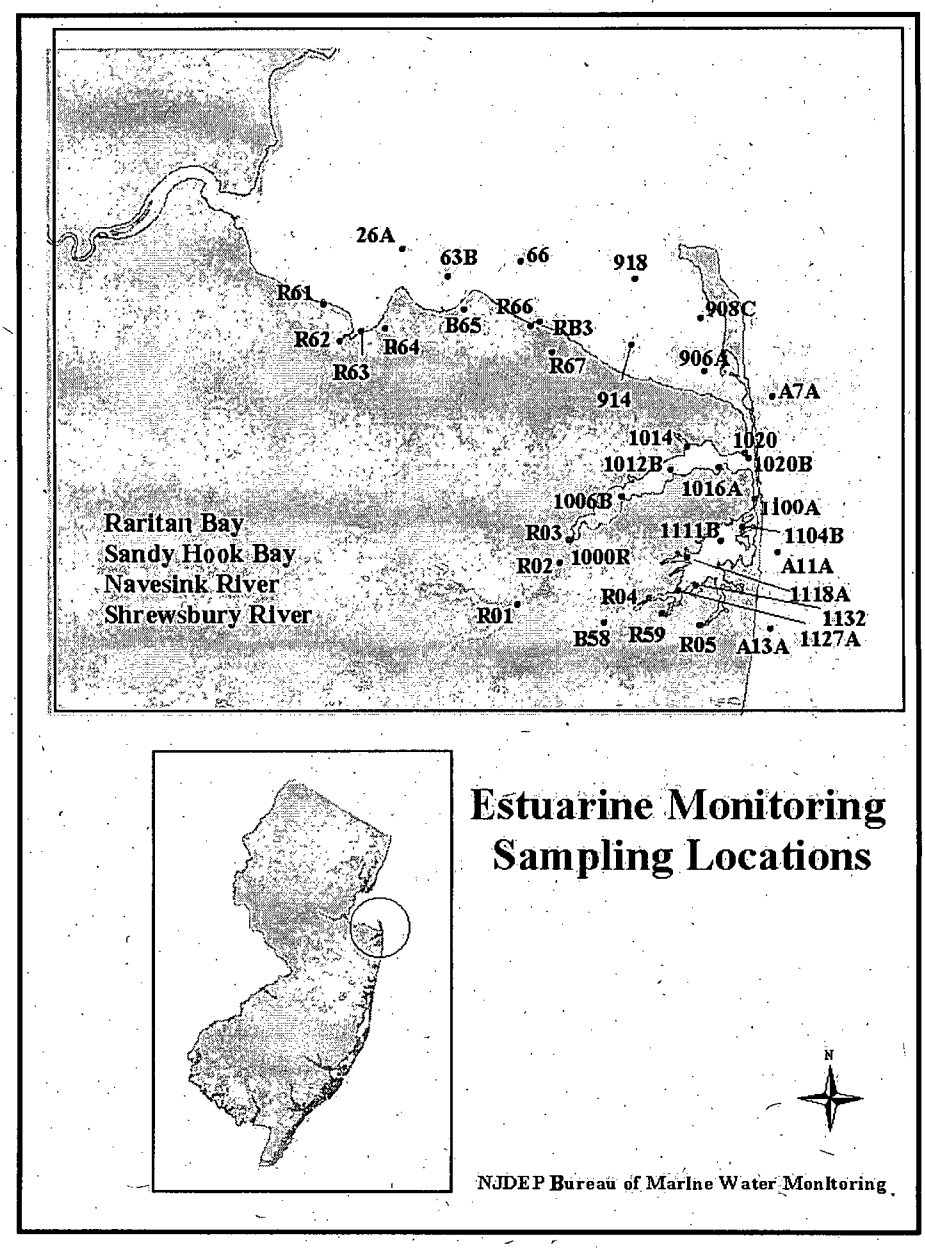



FIGURE 48: SAMPLING SITES WHERE ADDITIONAL DATA HAS BEEN COLLECTED FOR NUTRIENTS

## *INTERPETATION AND DISCUSSION OF DATA*

## BACTERIOLOGICAL

Bacteriological water quality in this area is impacted by rainfall, presumably as nonpoint source contributions to stormwater runoff.

It appears that water quality is significantly affected by one or more sources located in the western section of Raritan Bay. This impact does not preclude upgrading a small area west of Conaskonk Point at this time.

Water quality in the Flynn's Knoll area has improved so that the area should be upgraded to *Special Restricted* status. However, if and when the Army Corps of Engineers begins to use the area in New York State waters as a dredge spoil site for spoils from the Newark / New York harbor area, the harvest in the area should be suspended as a precautionary measure.

Water quality in the Sandy Hook Bay area has continued to improve. Data collected in this area in the winter after rainfall is consistent with *Seasonally Approved* status. However, there is not yet enough seasonal data to determine if the area should be upgraded.

## NUTRIENTS

The Bureau of Marine Water Monitoring publishes an annual summary of data collected in the estuarine monitoring program, as well as an in-depth analysis every 3-4 years. These reports are available for download in PDF format oh the Bureau's website at: www.state.nj.us/dep/watershedmgt/bmw.

In general, ambient concentrations in this area tend to be relatively high in both nitrogen and phosphorus, compared to other estuarine waterbodies. In addition, diurnal swings in dissolved oxygen are more pronounced than elsewhere. There are also frequent phytoplankton blooms.

## TOXICS

The tissue monitoring indicates that there are potentially several sources of toxicant inputs to this area.

1. In the Raritan, it appears that there are one or more sources of toxicants in the Keyport / Union Beach area.
2. The levels of chromium in the Atlantic Highlands Marina area are no longer a specific threat to human health. However, the area should remain in *Prohibited* status until such time as the levels have decreased to be similar to those

found throughout the remainder of the Bays.

3. It appears that the greater New York Harbor may also be a source of elevated levels of some toxicants, most notably PCBs, particularly at the tip of Sandy Hook and to the east of Sandy Hook.

## *CONCLUSIONS*

## BACTERIOLOGICAL EVALUATION

The data supports the current classification. In addition, the area known as Flynn's Knoll and a small area immediately to the west of Conaskonk Point should be upgraded to *Special Restricted* status.

## *RECOMMENDATIONS*

## BACTERIOLOGICAL EVALUATION

### *RECOMMENDED CLASSIFICATION CHANGES*

The area to the north and west of Sandy Hook, known as Flynn's Knoll, should be upgraded to *Special Restricted* status. This upgrade will open an additional 4750 acres to harvest under the Special Permits program.

The area in the western part of Raritan Bay (west of Keyport) should remain in *Prohibited* status at this time. A small area immediately to the west of Conaskonk Point (and north of Keyport) should be upgraded to *Special Restricted* status. This upgrade will open an additional 964 acres to harvest under the Special Permits program.

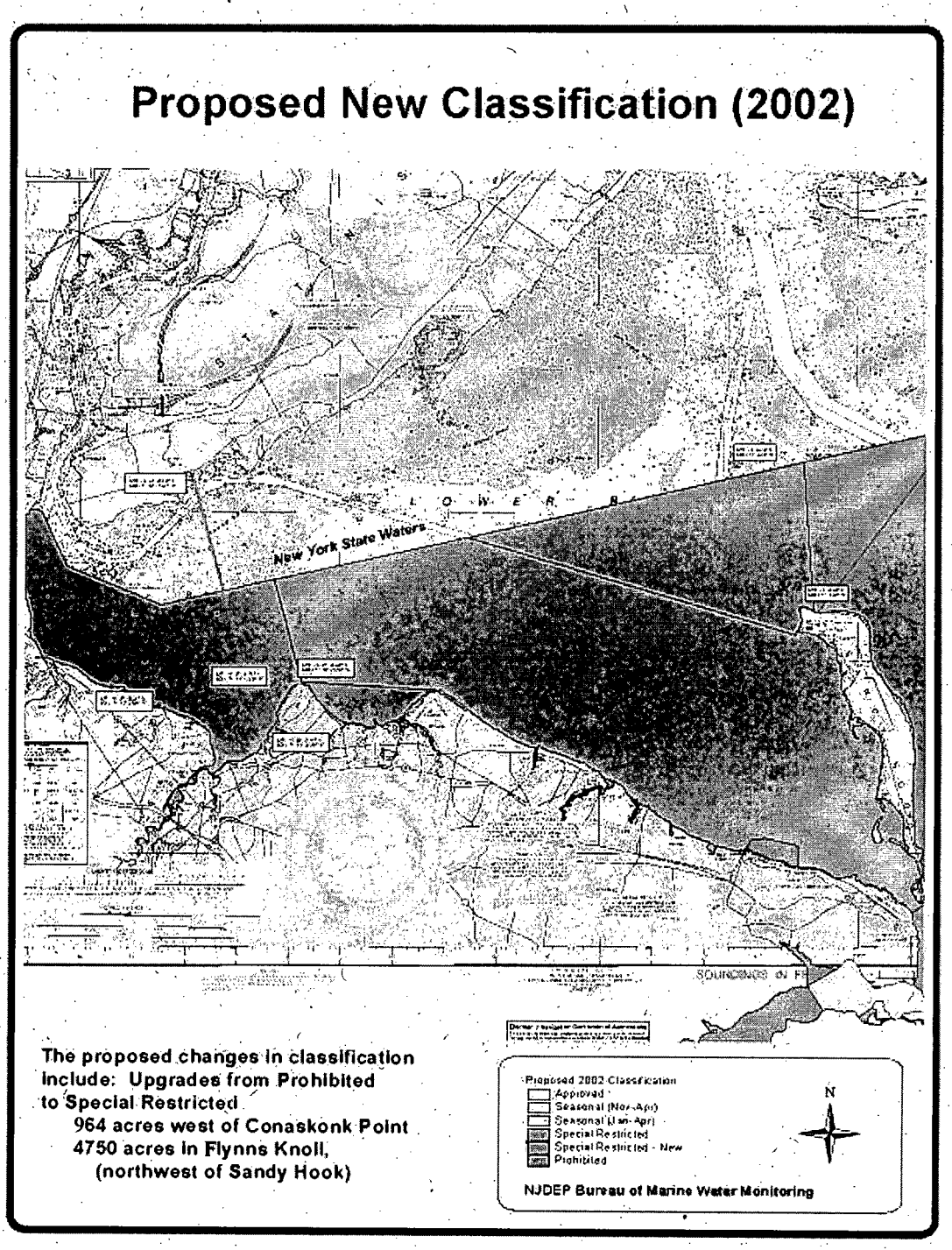



FIGURE 49: RECOMMENDED CHANGES IN CLASSIFICATION

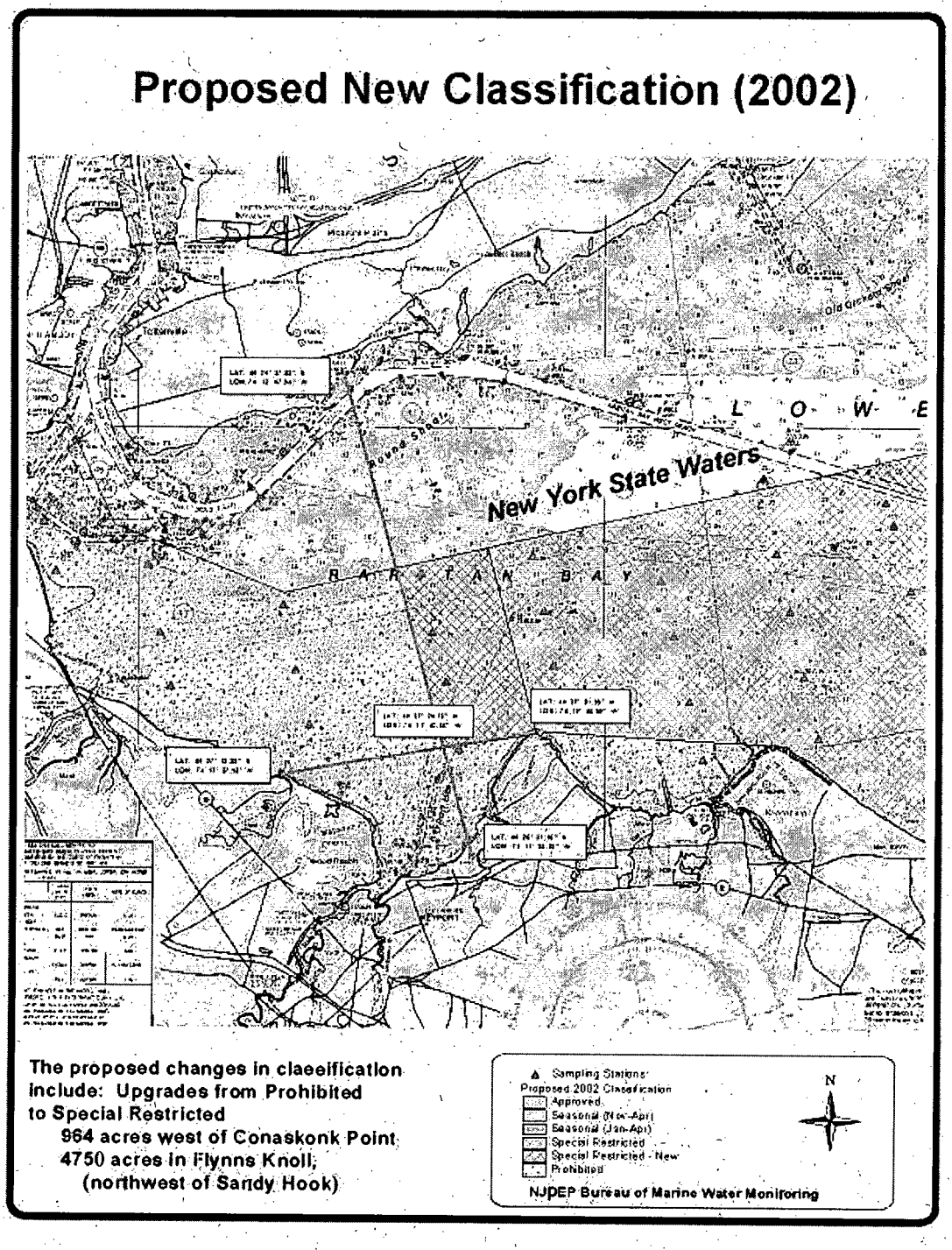



FIGURE 50: RECLASSIFICATION (WEST OF CONASKONK POINT)

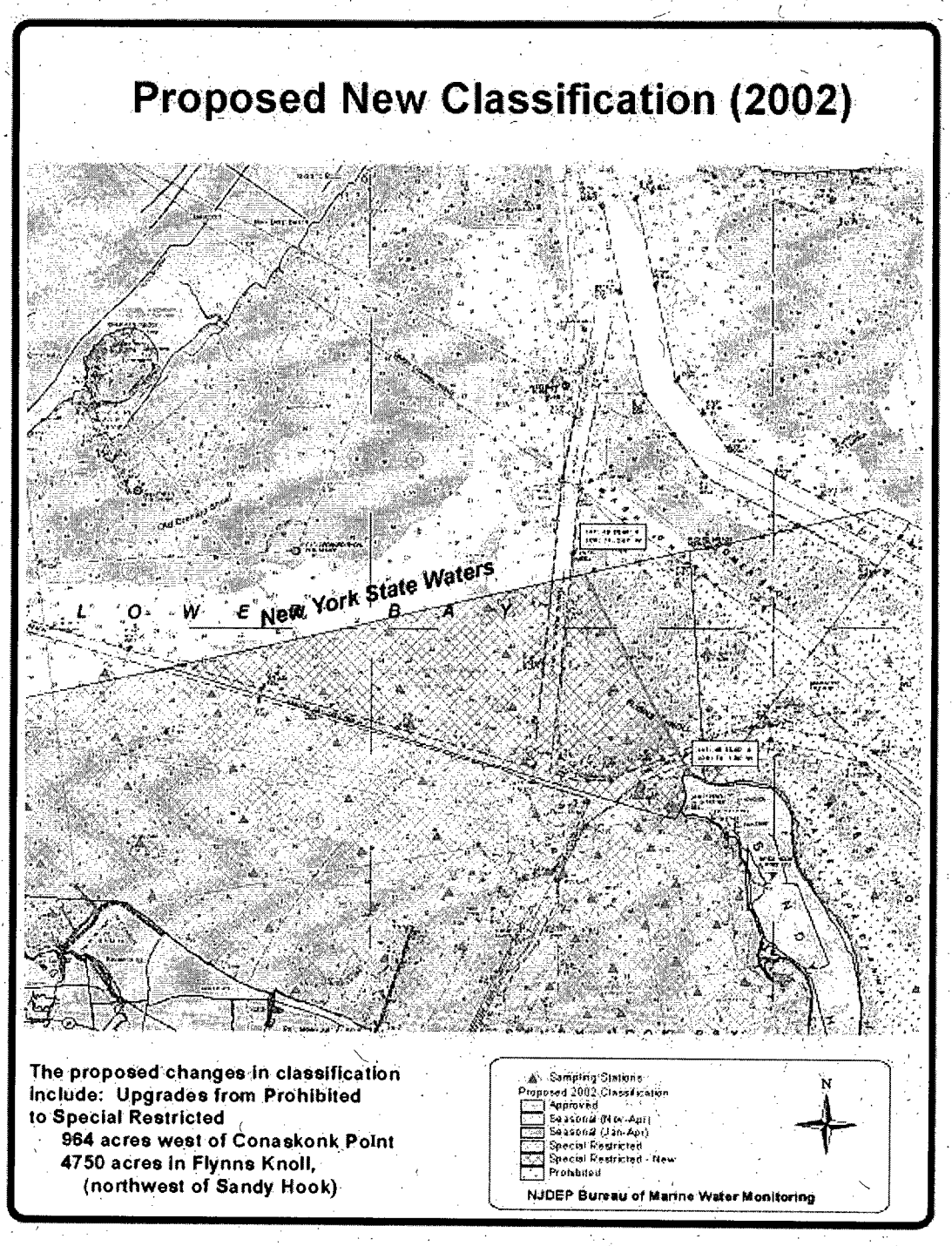



FIGURE 51: RECLASSIFICATION (FLYNN'S KNOLL)

## *LEGAL DESCRIPTION FOR RECOMMENDED CHANGES*

The following changes are recommended. These changes will upgrade 5714 acres from *Prohibited* status to *Special Restricted* status.

7:12-2.1 Shellfish growing water classification—Prohibited

3. Monmouth Middlesex County area (Note that a portion is also designated as a Special Restricted area. See N.J.A.C. 7:12-3):

i. All those waters of Raritan Bay, Raritan River and Arthur Kill (and tributaries) lying south and west of the New Jersey/New York boundary and lying west of a line beginning at the water tower in Keyport located at latitude 40° 26'31.16" N and longitude 74° 11' 25.18" W and continuing in a northwesterly direction at a bearing of 345 deprees T toward the tower loeated west of Princes Bay, Staten Island, New York, at latitude 40° 30' 27.82" N and longitude 74° 12' 47.94" W [on the northernmost point of land on Conaskonk Point, Union Beach, New Jersey and bearing approximately 345 degrees T to the southernmost point of land on Sequine Point, near Princes Bay, Staten Island, New York,] where this line terminates;

ii – iv. No Change

v. All those waters of Raritan Bay and Lower Bay enclosed by the New Jersey/New York boundary and a straight line beginning on the southwestemmost point of land on Rockaway Point, Long Island, New York and bearing approximately 222 degrees T to the northernmost point of land on Sandy Hook, New Jersey and then in a northwesterly direction for approximately 2.2 nautical miles bearing approximately 331 degrees toward R "10" 18 Fl R4s Bell, (located in New York State waters) until it intersects New York State waters at approximately latitude 40 degrees 30.59 minutes N and longitude 74 degrees 2.51 minutes W [following the shoreline of Sandy Hook west and south to a point on the shoreline where this line intersects a line beginning at the navigation aid at Sandy Hook Point designated as Equal Interval 6 second and Vertical Beam light 38ft 15M Bell (E. Int 6 sec and VB 38ft 15M Bell) and then following this line bearing approximately 278 degrees T to the channel marker designated as GR "TC" Interrupted Quick Green Light (GR "TC" Fl(2+1)(G6s)) located at the intersection of Raritan Bay East Reach, Sandy Hook Channel, and Terminal Channel, and then following the southwestemmost boundary of the Raritan Bay East Reach Channel in a northwesterly direction until it intersects the New Jersey/New York boundary] where this line terminates. (Note: This closure adjoins those Prohibited waters defined in (a)20i below); and

7:12-3.1 Use of shellfish grown in waters classified as Special Restricted for human consumption

Shellfish grown in waters classified as Special Restricted may be utilized for human consumption only pursuant to a special permit issued by Department under N.J.A.C. 7:12-9.

7:12-3.2 Shellfish growing waters that are classified as Special Restricted

(a) The following shellfish growing waters are classified as Special Restricted:

1. All those waters contained within a line beginning on the northernmost point of Conaskonk Point near Union Beach, New Jersey and bearing approximately 261 degrees T toward the northemmost point of Cliffwood Beach, New Jersey, located at latitude 40° 27' 12.39 N and longitude 74° 13' 27.98" W to a point located at latitude 40° 27' 24.78" N and longitude 74° 11' 43.86" W at the intersection of a line beginning at the water tower in Keyport located at latitude 40° 26' 31.16" N and longitude 74° 11' 25.18" W and extending at a bearing of approximately 345 degrees T toward a tower located near Princes Bay, Staten Island, New York, at latitude 40° 30' 27.82" N and longitude 74° 12' 47.94" W; then continuing northwesterly along that line at a bearing of approximately 345 degrees T to the intersection with New York State waters at latitude 40o 30' 27.82" N and longitude 74o 12' 13.79" W [345 degrees T to Sequine Point at Princes Bay, Staten Island, New York, until it intersects the New York-New Jersey boundary,] then along that boundary in an easterly direction until it intersects the Chapel Hill South Channel at approximately latitude 40 degrees 30.59 minutes N and longitude 74 degrees 2.51 minutes W (just south of R "10" 18 Fl R4s Bell, located in New York State waters), thence in a southeasterly direction at a bearing of 151 T to the northernmost tip of Sandy Hook, approximately latitude 40 degrees 28.68 minutes N and longitude 74 degrees 1.05 minutes W [Raritan Bay East Reach Channel, then along the southwest boundary of that channel in a southeasterly direction (approximate bearing 106 degrees T) to the channel marker designated as GR "TC" Interrupted Quick Flashing Green light (GR "TC" I QK Fl G) located at the intersection of Raritan Bay East Reach, Sandy Hook Channel and Terminal Channel, and then bearing approximately 098 degrees T to the navigation aid designated as "Equal Interval 6 second and vertical Beam light 38ft 15M Bell" (E. Int. 6 sec and VB 38ft 15M Bell) located on the shore at Sandy Hook Point], then proceeding in a generally southerly direction following the western shoreline of Sandy Hook to the westernmost extent of the Rt. 36 highway bridge spanning the Shrewsbury River and then following the northern edge of that bridge to where it intersects the shoreline on the mainland and then following the shoreline in a generally northwesterly direction until it intersects a line bearing approximately 201 degrees T from the navigational marker designated as Flashing light 4 second 29ft 8M (Fl 4 sec 29ft 8M) marking the easternmost extent of the Atlantic Highlands Municipal Yacht Basin's breakwater (this stonepile forms the basin's northern boundary), and then along that line in a northerly direction to the marker designated as a Flashing light 4 second 29ft 8M and following the northern side of the breakwater in a westerly direction until it reaches the structure forming the western boundary of the Yacht Basin, and then following the western edge of this structure in a southerly direction to the mainland, then following the shoreline in a generally northwesterly direction to the northernmost point of land on Point Comfort (Keansburg), then bearing approxiinately 272 degrees T to the northernmost point of land on Conaskonk Point (Union Beach), its point of origin.

### *RECOMMENDED CHANGES IN MONITORING SCHEDULE*

Additional samples should be collected after rainfall ih the winter in the Sandy Hook Bay area. It may be possible to upgrade this area to *Seasonally Approved* after sufficient data have been collected.

Samples collected in the area west of Keyport should be analyzed with an extra dilution. Numerous sampling results were greater than the maximum quantifiable using the threc-tube dilution procedure.

## RECOMMENDATIONS FOR FURTHER STUDY

1. The tissue toxics monitoring program should be continued. The differing signatures of PAHs ahd PCBs might be helpful in identifying sources of contamination in this area.

2. The estuarine monitoring program for nutrients and related parameters should be continued.

3. The sources of bacteriological contamination in the western portion of Raritan Bay should be identified and eliminated or reduced. Since this area has not been harvested for many years, it is likely that a significant resource exists in this area. In addition, there is significant interest on the part of the Baymen to restore this area for active harvest.

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# *APPENDICES*

Raw Data for 1997-2000

# *Shellfish Growing Water – Total Coliform Data Listing*

*New Jersey Department of Environmental Protection*

*Bureau of Marine Water Monitoring*

***Report Area:* NE1**

***NSSP Monitoring***

***Station:*** 10

TC-2-3T : Surface

Restricted

| | |
|---|---|
| *Geo Mean:* | 67.2 |
| *Est 90th:* | 2669.5 |
| *# Samples:* | 7 |
| 0.0% > | *3300* |

| *Date:* | *Results:* |
|---|---|
| 1/20/1999 | 1,600.0 |
| 1/26/1999 | 1,600.0 |
| 3/2/1999 | 4.0 |
| 3/30/1999 | 4.0 |
| 6/22/1999 | 3.0 K |
| 3/29/2000 | 110.0 |
| 7/27/2000 | 460.0 |

***Station:*** 18

TC-2-3T : Surface

Prohibited

| | |
|---|---|
| *Geo Mean:* | 348.9 |
| *Est 90th:* | 3310.7 |
| *# Samples:* | 7 |
| 0.0% > | *3300* |

| *Date:* | *Results:* |
|---|---|
| 1/20/1999 | 1,600.0 |
| 1/26/1999 | 1,600.0 |
| 3/2/1999 | 280.0 |
| 3/30/1999 | 17.0 |
| 6/22/1999 | 430.0 |
| 3/29/2000 | 1,600.0 |
| 7/27/2000 | 75.0 |

***Station:*** 20

TC-2-3T : Surface

Prohibited

| | |
|---|---|
| *Geo Mean:* | 354.8 |
| *Est 90th:* | 2466.3 |
| *# Samples:* | 7 |
| 0.0% > | *3300* |

| *Date:* | *Results:* |
|---|---|
| 1/20/1999 | 1,600.0 |
| 1/26/1999 | 1,600.0 |
| 3/2/1999 | 300.0 |
| 3/30/1999 | 30.0 |
| 6/22/1999 | 93.0 |
| 3/29/2000 | 300.0 |
| 7/27/2000 | 1,100.0 |

***Station:*** 20A

TC-2-3T : Surface

Prohibited

| | |
|---|---|
| *Geo Mean:* | 432.7 |
| *Est 90th:* | 4228.0 |
| *# Samples:* | 7 |
| 0.0% > | *3300* |

| *Date:* | *Results:* |
|---|---|
| 1/20/1999 | 1,600.0 L |
| 1/26/1999 | 1,600.0 |
| 3/2/1999 | 300.0 |
| 3/30/1999 | 14.0 |
| 6/22/1999 | 150.0 |
| 3/29/2000 | 1,600.0 |
| 7/27/2000 | 1,100.0 |

***Station:*** 21

TC-2-3T : Surface

Prohibited

| | |
|---|---|
| *Geo Mean:* | 280.3 |
| *Est 90th:* | 2293.6 |
| *# Samples:* | 7 |
| 0.0% > | *3300* |

| *Date:* | *Results:* |
|---|---|
| 1/20/1999 | 1,600.0 |
| 1/26/1999 | 1,600.0 |
| 3/2/1999 | 500.0 |
| 3/30/1999 | 22.0 |
| 6/22/1999 | 210.0 |
| 3/29/2000 | 50.0 |
| 7/27/2000 | 460.0 |

***Station:*** 23

TC-2-3T : Surface

Prohibited

| | |
|---|---|
| *Geo Mean:* | 278.6 |
| *Est 90th:* | 2163.9 |
| *# Samples:* | 7 |
| 0.0% > | *3300* |

| *Date:* | *Results:* |
|---|---|
| 1/20/1999 | 1,600.0 |
| 1/26/1999 | 900.0 |
| 3/2/1999 | 130.0 |
| 3/30/1999 | 14.0 |
| 6/22/1999 | 230.0 |
| 3/29/2000 | 900.0 |
| 7/27/2000 | 240.0 |

***Station:*** 24A

TC-2-3T : Surface

Restricted

| | |
|---|---|
| *Geo Mean:* | 133.8 |
| *Est 90th:* | 1784.3 |
| *# Samples:* | 16 |
| 0.0% > | *3300* |

| *Date:* | *Results:* |
|---|---|
| 5/8/1997 | 80.0 |
| 8/26/1997 | 15.0 |
| 2/19/1998 | 1,600.0 |
| 2/26/1998 | 21.0 |
| 3/10/1998 | 460.0 |
| 3/16/1998 | 8.0 |
| 3/23/1998 | 130.0 |
| 4/3/1998 | 1,600.0 L |
| 6/24/1998 | 3.0 K |
| 1/20/1999 | 1,600.0 |
| 1/26/1999 | 1,600.0 |
| 3/2/1999 | 170.0 |
| 3/30/1999 | 30.0 |
| 6/22/1999 | 390.0 |
| 3/29/2000 | 300.0 |
| 7/27/2000 | 75.0 |

***Station:*** 26A

TC-2-3T : Surface

Restricted

| | |
|---|---|
| *Geo Mean:* | 86.2 |
| *Est 90th:* | 2047.2 |
| *# Samples:* | 16 |
| 6.3% > | *3300* |

| *Date:* | *Results:* |
|---|---|
| 5/8/1997 | 23.0 |
| 8/26/1997 | 3.0 K |
| 2/19/1998 | 900.0 |
| 2/26/1998 | 13.0 |
| 3/10/1998 | 4,600.0 |
| 3/16/1998 | 13.0 |
| 3/23/1998 | 70.0 |
| 4/3/1998 | 1,600.0 L |
| 6/24/1998 | 3.0 K |
| 1/20/1999 | 1,600.0 |
| 1/26/1999 | 1,600.0 L |
| 3/2/1999 | 7.0 |
| 3/30/1999 | 11.0 |
| 6/22/1999 | 43.0 |
| 3/29/2000 | 280.0 |
| 7/27/2000 | 240.0 |

## *Report Area:* NE1

*Station:* 28

TC-2-3T : Surface
Restricted

| | |
|---|---|
| *Geo Mean:* | 71.9 |
| *Est 90th:* | 1749.9 |
| *# Samples:* | 15 |
| 0.0% > | *3300* |

| *Date:* | *Results:* |
|---|---|
| 5/8/1997 | 4.0 |
| 2/19/1998 | 500.0 |
| 2/26/1998 | 9.0 |
| 3/10/1998 | 750.0 |
| 3/16/1998 | 8.0 |
| 3/23/1998 | 50.0 |
| 4/3/1998 | 1,600.0 L |
| 6/24/1998 | 93.0 |
| 1/20/1999 | 1,600.0 L |
| 1/26/1999 | 1,600.0 |
| 3/2/1999 | 8.0 |
| 3/30/1999 | 2.0 |
| 6/22/1999 | 3.0 K |
| 3/29/2000 | 300.0 |
| 7/27/2000 | 240.0 |

*Station:* 29A

TC-2-3T : Surface
Restricted

| | |
|---|---|
| *Geo Mean:* | 108.6 |
| *Est 90th:* | 1605.4 |
| *# Samples:* | 16 |
| 0.0% > | *3300* |

| *Date:* | *Results:* |
|---|---|
| 5/8/1997 | 22.0 |
| 8/26/1997 | 3.0 K |
| 2/19/1998 | 500.0 |
| 2/26/1998 | 300.0 |
| 3/10/1998 | 1,500.0 |
| 3/16/1998 | 30.0 |
| 3/23/1998 | 130.0 |
| 4/3/1998 | 1,600.0 L |
| 6/24/1998 | 240.0 |
| 1/20/1999 | 500.0 |
| 1/26/1999 | 1,600.0 |
| 3/2/1999 | 11.0 |
| 3/30/1999 | 23.0 |
| 6/22/1999 | 3.0 K |
| 3/29/2000 | 300.0 |
| 7/27/2000 | 93.0 |

*Station:* 33A

TC-2-3T : Surface
Restricted

| | |
|---|---|
| *Geo Mean:* | 29.6 |
| *Est 90th:* | 596.1 |
| *# Samples:* | 7 |
| 0.0% > | *3300* |

| *Date:* | *Results:* |
|---|---|
| 1/19/1999 | 21.0 |
| 5/25/1999 | 3.6 |
| 6/15/1999 | 3.0 K |
| 7/20/1999 | 3.6 |
| 3/1/2000 | 240.0 |
| 3/23/2000 | 93.0 |
| 6/8/2000 | 1,100.0 |

*Station:* 36

TC-2-3T : Surface
Restricted

| | |
|---|---|
| *Geo Mean:* | 38.6 |
| *Est 90th:* | 724.6 |
| *# Samples:* | 15 |
| 0.0% > | *3300* |

| *Date:* | *Results:* |
|---|---|
| 5/8/1997 | 80.0 |
| 8/26/1997 | 7.3 |
| 2/19/1998 | 900.0 |
| 2/26/1998 | 13.0 |
| 3/16/1998 | 170.0 |
| 3/23/1998 | 300.0 |
| 4/3/1998 | 500.0 |
| 6/24/1998 | 3.0 |
| 1/19/1999 | 7.3 |
| 5/25/1999 | 3.0 K |
| 6/15/1999 | 3.0 K |
| 7/20/1999 | 3.6 |
| 3/1/2000 | 93.0 |
| 3/23/2000 | 23.0 |
| 6/8/2000 | 2,400.0 L |

*Station:* 38

TC-2-3T : Surface
Restricted

| | |
|---|---|
| *Geo Mean:* | 25.4 |
| *Est 90th:* | 577.2 |
| *# Samples:* | 15 |
| 0.0% > | *3300* |

| *Date:* | *Results:* |
|---|---|
| 5/8/1997 | 17.0 |
| 8/26/1997 | 3.0 K |
| 2/19/1998 | 900.0 |
| 2/26/1998 | 17.0 |
| 3/16/1998 | 30.0 |
| 3/23/1998 | 220.0 |
| 4/3/1998 | 1,600.0 |
| 6/24/1998 | 3.0 K |
| 1/19/1999 | 3.0 |
| 5/25/1999 | 9.1 |
| 6/15/1999 | 3.0 K |
| 7/20/1999 | 3.0 K |
| 3/1/2000 | 23.0 |
| 3/23/2000 | 3.6 |
| 6/8/2000 | 2,400.0 L |
| 6/8/2000 | 2,400.0 L |

*Station:* 43

TC-2-3T : Surface
Restricted

| | |
|---|---|
| *Geo Mean:* | 29.4 |
| *Est 90th:* | 454.8 |
| *# Samples:* | 15 |
| 0.0% > | *3300* |

| *Date:* | *Results:* |
|---|---|
| 5/8/1997 | 11.0 |
| 8/26/1997 | 3.0 K |
| 2/19/1998 | 500.0 |
| 2/26/1998 | 17.0 |
| 3/16/1998 | 11.0 |
| 3/23/1998 | 50.0 |
| 4/3/1998 | 1,600.0 |
| 6/24/1998 | 9.1 |
| 1/19/1999 | 93.0 |
| 5/25/1999 | 3.6 |
| 6/15/1999 | 3.0 K |
| 7/20/1999 | 3.0 K |
| 3/1/2000 | 93.0 |
| 3/23/2000 | 15.0 |
| 6/8/2000 | 1,100.0 |

*Station:* 47

TC-2-3T : Surface
Restricted

| | |
|---|---|
| *Geo Mean:* | 57.0 |
| *Est 90th:* | 487.7 |
| *# Samples:* | 8 |
| 0.0% > | *3300* |

| *Date:* | *Results:* |
|---|---|
| 5/8/1997 | 130.0 |
| 8/26/1997 | 9.1 |
| 2/19/1998 | 130.0 |
| 2/26/1998 | 50.0 |
| 3/10/1998 | 15.0 |
| 3/16/1998 | 14.0 |
| 4/3/1998 | 1,600.0 |
| 6/24/1998 | 43.0 |

*Station:* 49A

TC-2-3T : Surface
Restricted

| | |
|---|---|
| *Geo Mean:* | 44.6 |
| *Est 90th:* | 584.6 |
| *Est 90th:* | 584.6 |
| *# Samples:* | 16 |
| 0.0% > | *3300* |

| *Date:* | *Results:* |
|---|---|
| 5/8/1997 | 70.0 |
| 8/26/1997 | 3.0 K |
| 2/19/1998 | 220.0 |
| 2/26/1998 | 17.0 |
| 3/10/1998 | 2,400.0 |
| 3/16/1998 | 50.0 |
| 3/23/1998 | 30.0 |
| 4/3/1998 | 1,600.0 |
| 6/24/1998 | 23.0 |
| 1/19/1999 | 21.0 |
| 5/25/1999 | 120.0 |
| 6/15/1999 | 3.0 K |
| 7/20/1999 | 3.0 K |
| 3/1/2000 | 75.0 |
| 3/23/2000 | 9.1 |
| 6/8/2000 | 150.0 |

*Slation:* 5

TC-2-3T : Surface
Restricted

| | |
|---|---|
| *Geo Mean:* | 31.5 |
| *Est 90th:* | 628.1 |
| *# Samples:* | 6 |
| 0.0% > | *3300* |

| *Date:* | *Results:* |
|---|---|
| 1/19/1999 | 7.3 |
| 5/25/1999 | 7.2 |
| 7/20/1999 | 9.1 |
| 3/1/2000 | 93.0 |
| 3/23/2000 | 9.1 |
| 6/8/2000 | 2,400.0 L |

*Station:* 50

TC-2-3T : Surface
Restricted

| | |
|---|---|
| *Geo Mean:* | 63.4 |
| *Est 90th:* | |
| *Esi 90th:* | 1051.1 |
| *# Samples:* | 16 |
| 0.0% > | *3300* |
| 0.0% > | *3300* |
| 0.0% > | *3300* |

| *Date:* | *Results:* |
|---|---|
| 5/8/1997 | 80.0 |
| 8/26/1997 | 3.0 K |
| 2/19/1998 | 500.0 |
| 2/26/1998 | 7.0 |
| 3/10/1998 | 1,100.0 |
| 3/16/1998 | 34.0 |
| 3/23/1998 | 80.0 |
| 4/3/1998 | 1,600.0 L |
| 6/24/1998 | 240.0 |
| 1/20/1999 | 1,600.0 |
| 1/26/1999 | 300.0 |
| 3/2/1999 | 8.0 |
| 3/30/1999 | 17.0 |
| 6/22/1999 | 3.0 K |
| 3/29/2000 | 50.0 |
| 7/27/2000 | 7.3 |

## *Report Area:* NE1

*Station:*56

TC-2-3T : Surface
Restricted

| | |
|---|---|
| *Geo Mean:* | 206.3 |
| *Est 90th:* | 1761.8 |
| *# Samples:* | 16 |
| 0.0% > | *3300* |

| *Date:* | *Results:* |
|---|---|
| 5/8/1997 | 50.0 |
| 8/26/1997 | 93.0 |
| 2/19/1998 | 1,600.0 L |
| 2/26/1998 | 80.0 |
| 3/10/1998 | 1,100.0 |
| 3/16/1998 | 13.0 |
| 3/23/1998 | 130.0 |
| 4/3/1998 | 1,600.0 L |
| 6/24/1998 | 460.0 |
| 1/20/1999 | 1,600.0 |
| 1/26/1999 | 500.0 |
| 3/2/1999 | 240.0 |
| 3/30/1999 | 13.0 |
| 6/22/1999 | 23.0 |
| 3/29/2000 | 500.0 |
| 7/27/2000 | 460.0 |

*Station:*58

TC-2-3T : Surface
Prohibited

| | |
|---|---|
| *Geo Mean:* | 119.1 |
| *Est 90th:* | 1648.7 |
| *# Samples:* | 7 |
| 0.0% > | *3300* |

| *Date:* | *Results:* |
|---|---|
| 1/20/1999 | 1,600.0 |
| 1/26/1999 | 500.0 |
| 3/2/1999 | 280.0 |
| 3/30/1999 | 22.0 |
| 6/22/1999 | 3.6 |
| 3/29/2000 | 80.0 |
| 7/27/2000 | 240.0 |

*Station:*61A

TC-2-3T : Surface
Prohibited

| | |
|---|---|
| *Geo Mean:* | 90.1 |
| *Est 90th:* | 1780.6 |
| *# Samples:* | 15 |
| 0.0% > | *3300* |

| *Date:* | *Results:* |
|---|---|
| 5/8/1997 | 110.0 |
| 8/26/1997 | 9.1 |
| 2/19/1998 | 240.0 |
| 2/26/1998 | 50.0 |
| 3/16/1998 | 4.0 |
| 3/23/1998 | 70.0 |
| 4/3/1998 | 1,600.0 L |
| 6/24/1998 | 3.6 |
| 1/20/1999 | 1,600.0 |
| 1/26/1999 | 1,600.0 |
| 3/2/1999 | 500.0 |
| 3/30/1999 | 13.0 |
| 6/22/1999 | 3.0 K |
| 3/29/2000 | 900.0 |
| 7/27/2000 | 240.0 |

*Station:*62

TC-2-3T : Surface
Restricted

| | |
|---|---|
| *Geo Mean:* | 56.3 |
| *Est 90th:* | 1118.5 |
| *# Samples:* | 16 |
| 0.0% > | *3300* |

| *Date:* | *Results:* |
|---|---|
| 5/8/1997 | 170.0 |
| 8/26/1997 | 9.1 |
| 2/19/1998 | 500.0 |
| 2/26/1998 | 50.0 |
| 3/10/1998 | 1,100.0 |
| 3/16/1998 | 4.0 |
| 3/23/1998 | 30.0 |
| 4/3/1998 | 1,600.0 L |
| 6/24/1998 | 3.6 |
| 1/20/1999 | 1,600.0 |
| 1/26/1999 | 350.0 |
| 3/2/1999 | 14.0 |
| 3/30/1999 | 2.0 |
| 6/22/1999 | 3.0 K |
| 3/29/2000 | 170.0 |
| 7/27/2000 | 43.0 |

*Station:*63B

TC-2-3T : Surface
Restricted

| | |
|---|---|
| *Geo Mean:* | 47.0 |
| *Est 90th:* | 912.5 |
| *# Samples:* | 16 |
| 0.0% > | *3300* |

| *Date:* | *Results:* |
|---|---|
| 5/8/1997 | 80.0 |
| 8/26/1997 | 3.6 |
| 2/19/1998 | 900.0 |
| 2/26/1998 | 30.0 |
| 3/10/1998 | 460.0 |
| 3/16/1998 | 8.0 |
| 3/23/1998 | 170.0 |
| 4/3/1998 | 1,600.0 L |
| 6/24/1998 | 3.0 K |
| 1/20/1999 | 1,600.0 |
| 1/26/1999 | 220.0 |
| 3/2/1999 | 9.0 |
| 3/30/1999 | 2.0 |
| 6/22/1999 | 3.6 |
| 3/29/2000 | 50.0 |
| 7/27/2000 | 21.0 |

*Station:*7

TC-2-3T : Surface
Restricted

| | |
|---|---|
| *Geo Mean:* | 18.9 |
| *Est 90th:* | 396.8 |
| *# Samples:* | 7 |
| 0.0% > | *3300* |

| *Date:* | *Results:* |
|---|---|
| 1/19/1999 | 3.0 |
| 5/25/1999 | 3.0 |
| 6/15/1999 | 3.6 |
| 7/20/1999 | 11.0 |
| 3/1/2000 | 23.0 |
| 3/23/2000 | 43.0 |
| 6/8/2000 | 2,400.0 L |

*Station:*73

TC-2-3T : Surface
Restricted

| | |
|---|---|
| *Geo Mean:* | 25.5 |
| *Est 90th:* | 356.3 |
| *# Samples:* | 15 |
| 0.0% > | *3300* |

| *Date:* | *Results:* |
|---|---|
| 5/8/1997 | 11.0 |
| 8/26/1997 | 3.0 K |
| 2/19/1998 | 240.0 |
| 2/26/1998 | 8.0 |
| 3/16/1998 | 11.0 |
| 3/23/1998 | 80.0 |
| 4/3/1998 | 500.0 |
| 6/24/1998 | 3.6 |
| 1/19/1999 | 16.0 |
| 5/25/1999 | 43.0 |
| 6/15/1999 | 3.0 K |
| 7/20/1999 | 3.0 K |
| 3/1/2000 | 93.0 |
| 3/23/2000 | 9.1 |
| 6/8/2000 | 2,400.0 L |

*Station:*78

TC-2-3T : Surface
Restricted

| | |
|---|---|
| *Geo Mean:* | 26.9 |
| *Est 90th:* | 503.2 |
| *# Samples:* | 15 |
| 0.0% > | *3300* |

| *Date:* | *Results:* |
|---|---|
| 5/8/1997 | 30.0 |
| 8/26/1997 | 3.0 K |
| 2/19/1998 | 900.0 |
| 2/26/1998 | 11.0 |
| 3/16/1998 | 30.0 |
| 3/23/1998 | 110.0 |
| 4/3/1998 | 500.0 |
| 6/24/1998 | 9.1 |
| 1/19/1999 | 3.6 |
| 5/25/1999 | 3.6 |
| 6/15/1999 | 3.0 K |
| 7/20/1999 | 3.0 K |
| 3/1/2000 | 460.0 |
| 3/23/2000 | 3.6 |
| 6/8/2000 | 1,100.0 |

*Station:*86A

TC-2-3T : Surface
Restricted

| | |
|---|---|
| *Geo Mean:* | 44.5 |
| *Est 90th:* | 789.7 |
| *# Samples:* | 16 |
| 0.0% > | *3300* |

| *Date:* | *Results:* |
|---|---|
| 5/8/1997 | 14.0 |
| 8/26/1997 | 9.1 |
| 2/19/1998 | 300.0 |
| 2/26/1998 | 13.0 |
| 3/10/1998 | 460.0 |
| 3/16/1998 | 2.0 |
| 3/23/1998 | 110.0 |
| 4/3/1998 | 1,600.0 L |
| 6/24/1998 | 43.0 |
| 1/20/1999 | 1,600.0 |
| 1/26/1999 | 240.0 |
| 3/2/1999 | 4.0 |
| 3/30/1999 | 4.0 |
| 6/22/1999 | 3.6 |
| 3/29/2000 | 13.0 |
| 7/27/2000 | 240.0 |

*Station:*88A

TC-2-3T : Surface
Restricted

| | |
|---|---|
| *Geo Mean:* | 34.7 |
| *Est 90th:* | 749.5 |
| *# Samples:* | 15 |
| 0.0% > | *3300* |

| *Date:* | *Results:* |
|---|---|
| 5/8/1997 | 17.0 |
| 8/26/1997 | 3.0 |
| 2/19/1998 | 240.0 |
| 2/26/1998 | 30.0 |
| 3/10/1998 | 1,100.0 |
| 3/16/1998 | 30.0 |
| 3/23/1998 | 50.0 |
| 4/3/1998 | 1,600.0 L |
| 6/24/1998 | 3.0 K |
| 1/20/1999 | 1,600.0 |
| 1/26/1999 | 80.0 |
| 3/30/1999 | 2.0 |
| 6/22/1999 | 3.0 K |
| 3/29/2000 | 2.0 |
| 7/27/2000 | 28.0 |

## *Report Area:* NE1

*Station:*906A

TC-2-3T : Surface
Restricted

| | |
|---|---|
| *Geo Mean:* | 11.6 |
| *Est 90th:* | 90.4 |
| *# Samples:* | 14 |
| 0.0% > | *3300* |

| *Date:* | *Results:* |
|---|---|
| 5/8/1997 | 22.0 |
| 8/26/1997 | 43.0 |
| 2/19/1998 | 2.0 K |
| 3/16/1998 | 2.0 K |
| 3/23/1998 | 30.0 |
| 4/3/1998 | 11.0 |
| 6/24/1998 | 23.0 |
| 1/19/1999 | 3.0 |
| 5/25/1999 | 460.0 |
| 6/15/1999 | 3.6 |
| 7/20/1999 | 3.6 |
| 3/1/2000 | 7.3 |
| 3/23/2000 | 3.0 K |
| 6/8/2000 | 75.0 |

*Station:*906B

TC-2-3T : Surface
Restricted

| | |
|---|---|
| *Geo Mean:* | 7.3 |
| *Est 90th:* | 41.7 |
| *# Samples:* | 15 |
| 0.0% > | *3300* |

| *Date:* | *Results:* |
|---|---|
| 5/8/1997 | 50.0 |
| 8/26/1997 | 3.0 K |
| 2/19/1998 | 2.0 K |
| 2/26/1998 | 17.0 |
| 3/16/1998 | 2.0 K |
| 3/23/1998 | 9.0 |
| 4/3/1998 | 7.0 |
| 6/24/1998 | 23.0 |
| 1/19/1999 | 3.0 K |
| 5/25/1999 | 240.0 |
| 6/15/1999 | 3.0 K |
| 7/20/1999 | 3.0 K |
| 3/1/2000 | 3.6 |
| 3/23/2000 | 9.1 |
| 6/8/2000 | 3.0 K |

*Station:*906C

TC-2-3T : Surface
Restricted

| | |
|---|---|
| *Geo Mean:* | 5.6 |
| *Est 90th:* | 17.6 |
| *# Samples:* | 15 |
| 0.0% > | *3300* |

| *Date:* | *Results:* |
|---|---|
| 5/8/1997 | 13.0 |
| 8/26/1997 | 3.6 |
| 2/19/1998 | 2.0 K |
| 2/26/1998 | 30.0 |
| 3/16/1998 | 2.0 K |
| 3/23/1998 | 23.0 |
| 4/3/1998 | 13.0 |
| 6/24/1998 | 9.1 |
| 1/19/1999 | 3.0 K |
| 5/25/1999 | 3.0 K |
| 6/15/1999 | 3.0 K |
| 7/20/1999 | 3.6 |
| 3/1/2000 | 11.0 |
| 3/23/2000 | 3.6 |
| 6/8/2000 | 3.0 |

*Station:*907

TC-2-3T : Surface
Restricted

| | |
|---|---|
| *Geo Mean:* | 10.5 |
| *Est 90th:* | 49.3 |
| *# Samples:* | 14 |
| 0.0% > | *3300* |

| *Date:* | *Results:* |
|---|---|
| 5/8/1997 | 4.0 |
| 8/26/1997 | 7.3 |
| 2/19/1998 | 2.0 K |
| 3/16/1998 | 9.0 |
| 3/23/1998 | 4.0 |
| 4/3/1998 | 34.0 |
| 6/24/1998 | 43.0 |
| 1/19/1999 | 3.0 |
| 5/25/1999 | 93.0 |
| 6/15/1999 | 7.3 |
| 7/20/1999 | 29.0 |
| 3/1/2000 | 3.6 |
| 3/23/2000 | 7.3 |
| 6/8/2000 | 43.0 |

*Station:*908

TC-2-3T : Surface
Restricted

| | |
|---|---|
| *Geo Mean:* | 12.4 |
| *Est 90th:* | 68.4 |
| *# Samples:* | 13 |
| 0.0% > | *3300* |

| *Date:* | *Results:* |
|---|---|
| 5/8/1997 | 11.0 |
| 2/19/1998 | 2.0 K |
| 3/16/1998 | 2.0 |
| 3/23/1998 | 13.0 |
| 4/3/1998 | 170.0 |
| 6/24/1998 | 23.0 |
| 1/19/1999 | 7.3 |
| 5/25/1999 | 93.0 |
| 6/15/1999 | 3.0 K |
| 7/20/1999 | 23.0 |
| 3/1/2000 | 23.0 |
| 3/23/2000 | 9.1 |
| 6/8/2000 | 7.2 |

*Station:*908C

TC-2-3T : Surface
Restricted

| | |
|---|---|
| *Geo Mean:* | 8.0 |
| *Est 90th:* | 41.0 |
| *# Samples:* | 15 |
| 0.0% > | *3300* |

| *Date:* | *Results:* |
|---|---|
| 5/8/1997 | 30.0 |
| 8/26/1997 | 3.6 |
| 2/19/1998 | 2.0 |
| 2/26/1998 | 9.0 |
| 3/16/1998 | 2.0 K |
| 3/23/1998 | 17.0 |
| 4/3/1998 | 170.0 |
| 6/24/1998 | 3.6 |
| 1/19/1999 | 9.1 |
| 5/25/1999 | 3.6 |
| 6/15/1999 | 3.6 |
| 7/20/1999 | 3.0 K |
| 3/1/2000 | 43.0 |
| 3/23/2000 | 3.6 |
| 6/8/2000 | 15.0 |

*Station:*910

TC-2-3T : Surface
Prohibited

| | |
|---|---|
| *Geo Mean:* | 15.5 |
| *Est 90th:* | 218.5 |
| *# Samples:* | 5 |
| 0.0% > | *3300* |

| *Date:* | *Results:* |
|---|---|
| 2/19/1998 | 2.0 K |
| 3/16/1998 | 2.0 K |
| 3/23/1998 | 22.0 |
| 4/3/1998 | 240.0 |
| 6/24/1998 | 43.0 |

*Station:*910A

TC-2-3T : Surface
Restricted

| | |
|---|---|
| *Geo Mean:* | 18.2 |
| *Est 90th:* | 149.3 |
| *# Samples:* | 8 |
| 0.0% > | *3300* |

| *Date:* | *Results:* |
|---|---|
| 5/8/1997 | 4.0 |
| 1/19/1999 | 15.0 |
| 5/25/1999 | 240.0 |
| 6/15/1999 | 23.0 |
| 6/15/1999 | 23.0 |
| 7/20/1999 | 3.0 |
| 3/1/2000 | 93.0 |
| 3/1/2000 | 93.0 |
| 3/23/2000 | 3.0 K |
| 6/8/2000 | 43.0 |

*Station:*910E

TC-2-3T : Surface
Restricted

| | |
|---|---|
| *Geo Mean:* | 11.0 |
| *Est 90th:* | 83.0 |
| *# Samples:* | 15 |
| 0.0% > | *3300* |

| *Date:* | *Results:* |
|---|---|
| 5/8/1997 | 13.0 |
| 8/26/1997 | 3.0 K |
| 2/19/1998 | 17.0 |
| 2/26/1998 | 50.0 |
| 3/16/1998 | 2.0 |
| 3/23/1998 | 13.0 |
| 4/3/1998 | 500.0 |
| 6/24/1998 | 23.0 |
| 1/19/1999 | 23.0 |
| 5/25/1999 | 3.0 K |
| 6/15/1999 | 3.0 |
| 7/20/1999 | 3.0 K |
| 3/1/2000 | 75.0 |
| 3/1/2000 | 75.0 |
| 3/23/2000 | 3.0 K |
| 6/8/2000 | 3.0 K |

*Stdtion:*911

TC-2-3T : Surface
Restricted

| | |
|---|---|
| *Geo Mean:* | 9.0 |
| *Geo Mean:* | 9.0 |
| *Geo Mean:* | 9.0 |
| *Est 90th:* | 30.7 |
| *Est 90th:* | 30.7 |
| *# Samples:* | 7 |
| 0.0% > | *3300* |

| *Date:* | *Results:* |
|---|---|
| 1/19/1999 | 7.3 |
| 5/25/1999 | 20.0 |
| 6/15/1999 | 9.1 |
| 7/20/1999 | 3.0 |
| 3/1/2000 | 43.0 |
| 3/23/2000 | 9.1 |
| 6/8/2000 | 3.0 K |

## *Report Area:* NE1

*Station:* 911A

TC-2-3T : Surface
Restricted

| | |
|---|---|
| *Geo Mean:* | 11.2 |
| *Est 90th:* | 80.8 |
| *# Samples:* | 7 |
| 0.0% > | *3300* |

| *Date:* | *Results:* |
|---|---|
| 1/19/1999 | 7.3 |
| 5/25/1999 | 21.0 |
| 6/15/1999 | 3.6 |
| 7/20/1999 | 15.0 |
| 3/1/2000 | 240.0 |
| 3/23/2000 | 3.0 K |
| 6/8/2000 | 3.6 |

*Station:* 912

TC-2-3T : Surface
Restricted

| | |
|---|---|
| *Geo Mean:* | 12.3 |
| *Est 90th:* | 105.8 |
| *# Samples:* | 13 |
| 0.0% > | *3300* |

| *Date:* | *Results:* |
|---|---|
| 5/8/1997 | 27.0 |
| 2/19/1998 | 2.0 K |
| 3/16/1998 | 2.0 |
| 3/23/1998 | 9.0 |
| 16 | 376.2 |
| 4/3/1998 | 240.0 |
| 6/24/1998 | 3.6 |
| 1/19/1999 | 240.0 |
| 5/25/1999 | 39.0 |
| 6/15/1999 | 3.6 |
| 7/20/1999 | 3.6 |
| 3/1/2000 | 43.0 |
| 3/23/2000 | 3.6 |
| 6/8/2000 | 9.1 |

*Station:* 914

TC-2-3T : Surface
Restricted

| | |
|---|---|
| *Geo Mean:* | 12.9 |
| *Est 90th:* | 124.9 |
| *# Samples:* | 13 |
| 0.0% > | *3300* |

| *Date:* | *Results:* |
|---|---|
| 5/8/1997 | 8.0 |
| 2/19/1998 | 4.0 |
| 3/16/1998 | 4.0 |
| 3/23/1998 | 2.0 |
| 4/3/1998 | 500.0 |
| 6/24/1998 | 7.3 |
| 1/19/1999 | 240.0 |
| 5/25/1999 | 9.1 |
| 6/15/1999 | 7.3 |
| 7/20/1999 | 3.0 K |
| 3/1/2000 | 93.0 |
| 3/23/2000 | 3.0 K |
| 6/8/2000 | 23.0 |

*Station:* 914D

TC-2-3T : Surface
Restricted

| | |
|---|---|
| *Geo Mean:* | 14.7 |
| *Est 90th:* | 128.9 |
| *# Samples:* | 14 |
| 0.0% > | *3300* |

| *Date:* | *Results:* |
|---|---|
| 5/8/1997 | 23.0 |
| 8/26/1997 | 3.0 K |
| 2/19/1998 | 80.0 |
| 2/26/1998 | 11.0 |
| 3/16/1998 | 2.0 |
| 3/23/1998 | 14.0 |
| 4/3/1998 | 280.0 |
| 6/24/1998 | 3.0 K |
| 5/25/1999 | 3.0 K |
| 6/15/1999 | 7.3 |
| 7/20/1999 | 3.6 |
| 3/1/2000 | 93.0 |
| 3/23/2000 | 9.1 |
| 6/8/2000 | 240.0 |

*Station:* 916A

TC-2-3T : Surface
Restricted

| | |
|---|---|
| *Geo Mean:* | 27.6 |
| *Est 90th:* | 301.1 |
| *# Samples:* | 16 |
| 0.0% > | *3300* |

| *Date:* | *Results:* |
|---|---|
| 5/8/1997 | 22.0 |
| 8/26/1997 | 3.0 K |
| 2/19/1998 | 50.0 |
| 2/26/1998 | 170.0 |
| 3/10/1998 | 150.0 |
| 3/16/1998 | 2.0 |
| 3/23/1998 | 50.0 |
| 4/3/1998 | 130.0 |
| 6/24/1998 | 7.3 |
| 1/19/1999 | 460.0 |
| 5/25/1999 | 9.1 |
| 6/15/1999 | 3.6 |
| 7/20/1999 | 3.0 K |
| 3/1/2000 | 93.0 |
| 3/23/2000 | 7.3 |
| 6/8/2000 | 460.0 |

*Station:* 916C

TC-2-3T : Surface
Restricted

| | |
|---|---|
| *Geo Mean:* | 14.2 |
| *Est 90th:* | 158.3 |
| *Est 90th:* | 158.3 |
| *# Samples:* | 15 |
| 0.0% > | *3300* |

| *Date:* | *Results:* |
|---|---|
| 5/8/1997 | 30.0 |
| 8/26/1997 | 3.0 K |
| 2/19/1998 | 2.0 |
| 2/26/1998 | 220.0 |
| 3/10/1998 | 390.0 |
| 3/16/1998 | 2.0 |
| 3/23/1998 | 34.0 |
| 4/3/1998 | 500.0 |
| 6/24/1998 | 11.0 |
| 1/19/1999 | 9.1 |
| 5/25/1999 | 6.2 |
| 6/15/1999 | 3.6 |
| 7/20/1999 | 3.0 K |
| 3/1/2000 | 15.0 |
| 3/23/2000 | 3.6 |

*Station:* 916D

TC-2-3T : Surface
Restricted

| | |
|---|---|
| *Geo Mean:* | 20.6 |
| *Est 90th:* | 144.0 |
| *# Samples:* | 16 |
| 0.0% > | *3300* |

| *Date:* | *Results:* |
|---|---|
| 5/8/1997 | 17.0 |
| 8/26/1997 | 3.0 K |
| 2/19/1998 | 23.0 |
| 2/26/1998 | 80.0 |
| 3/10/1998 | 23.0 |
| 3/16/1998 | 30.0 |
| 3/23/1998 | 110.0 |
| 4/3/1998 | 170.0 |
| 6/24/1998 | 43.0 |
| 1/19/1999 | 7.3 |
| 5/25/1999 | 11.0 |
| 6/15/1999 | 3.0 K |
| 7/20/1999 | 3.6 |
| 3/1/2000 | 14.0 |
| 3/23/2000 | 3.6 |
| 6/8/2000 | 460.0 |

*Station:* 918

TC-2-3T : Surface
Restricted

| | |
|---|---|
| *Geo Mean:* | 22.0 |
| *Est 90th:* | 275.3 |
| *Est 90th:* | 275.3 |
| *# Samples:* | 15 |
| 0.0% > | *3300* |

| *Date:* | *Results:* |
|---|---|
| 5/8/1997 | 30.0 |
| 8/26/1997 | 3.0 K |
| 2/19/1998 | 300.0 |
| 2/26/1998 | 22.0 |
| 3/16/1998 | 13.0 |
| 3/23/1998 | 27.0 |
| 4/3/1998 | 500.0 |
| 6/24/1998 | 3.6 |
| 1/19/1999 | 3.0 K |
| 5/25/1999 | 15.0 |
| 6/15/1999 | 3.0 K |
| 7/20/1999 | 3.0 K |
| 3/1/2000 | 93.0 |
| 3/23/2000 | 9.1 |
| 6/8/2000 | 1,100.0 |

*Station:* 93A

TC-2-3T : Surface
Restricted

| | |
|---|---|
| *Geo Mean:* | 21.1 |
| *Est 90th:* | 218.5 |
| *# Samples:* | 15 |
| 0.0% > | *3300* |

| *Date:* | *Results:* |
|---|---|
| 5/8/1997 | 17.0 |
| 8/26/1997 | 3.0 K |
| 2/19/1998 | 130.0 |
| 2/26/1998 | 30.0 |
| 3/16/1998 | 30.0 |
| 3/23/1998 | 240.0 |
| 4/3/1998 | 500.0 |
| 6/24/1998 | 3.6 |
| 1/19/1999 | 23.0 |
| 5/25/1999 | 3.0 |
| 6/15/1999 | 3.6 |
| 7/20/1999 | 3.6 |
| 3/1/2000 | 43.0 |
| 3/23/2000 | 3.0 K |
| 6/8/2000 | 240.0 |

*Station:* 97A

TC-2-3T : Surface
Restricted

| | |
|---|---|
| *Geo Mean:* | 43.2 |
| *Geo Mean:* | 43.2 |
| *Est 90th:* | 376.2 |
| *Est 90th:* | *# Samples:* |
| *# Samples:* | 16 |
| 0.0% > | *3300* |

| *Date:* | *Results:* |
|---|---|
| 5/8/1997 | 130.0 |
| 8/26/1997 | 3.6 |
| 2/19/1998 | 240.0 |
| 2/26/1998 | 130.0 |
| 3/10/1998 | 28.0 |
| 3/16/1998 | 4.0 |
| 3/23/1998 | 80.0 |
| 4/3/1998 | 900.0 |
| 6/24/1998 | 15.0 |
| 1/19/1999 | 15.0 |
| 5/25/1999 | 43.0 |
| 6/15/1999 | 23.0 |
| 7/20/1999 | 3.0 K |
| 3/1/2000 | 93.0 |
| 3/23/2000 | 43.0 |
| 6/8/2000 | 460.0 |

## *Report Area:* NE1

*Station:*97B

TC-2-3T : Surface
Restricted

| | |
|---|---|
| *Geo Mean:* | 24.4 |
| *Est 90th:* | 267.9 |
| *# Samples:* | 16 |
| 0.0% > | *3300* |

| *Date:* | *Results:* |
|---|---|
| 5/8/1997 | 50.0 |
| 8/26/1997 | 3.0 K |
| 2/19/1998 | 4.0 |
| 2/26/1998 | 80.0 |
| 3/10/1998 | 93.0 |
| 3/16/1998 | 8.0 |
| 3/23/1998 | 130.0 |
| 4/3/1998 | 900.0 |
| 6/24/1998 | 9.1 |
| 1/19/1999 | 20.0 |
| 5/25/1999 | 15.0 |
| 6/15/1999 | 3.0 K |
| 7/20/1999 | 3.0 K |
| 3/1/2000 | 93.0 |
| 3/23/2000 | 3.6 |
| 6/8/2000 | 460.0 |

*Station:*98A

TC-2-3T : Surface
Restricted

| | |
|---|---|
| *Geo Mean:* | 18.2 |
| *Est 90th:* | 225.4 |
| *# Samples:* | 7 |
| 0.0% > | *3300* |

| *Date:* | *Results:* |
|---|---|
| 1/19/1999 | 11.0 |
| 5/25/1999 | 93.0 |
| 6/15/1999 | 3.0 K |
| 7/20/1999 | 3.0 K |
| 3/1/2000 | 43.0 |
| 3/23/2000 | 3.6 |
| 6/8/2000 | 460.0 |

*Station:*98

TC-2-3T : Surface
Restricted

| | |
|---|---|
| *Geo Mean:* | 25.2 |
| *Est 90th:* | 417.7 |
| *# Samples:* | 7 |
| 0.0% > | *3300* |

| *Date:* | *Results:* |
|---|---|
| 1/19/1999 | 28.0 |
| 5/25/1999 | 290.0 |
| 6/15/1999 | 3.0 K |
| 7/20/1999 | 3.0 K |
| 3/1/2000 | 460.0 |
| 3/23/2000 | 3.0 K |
| 6/8/2000 | 64.0 |